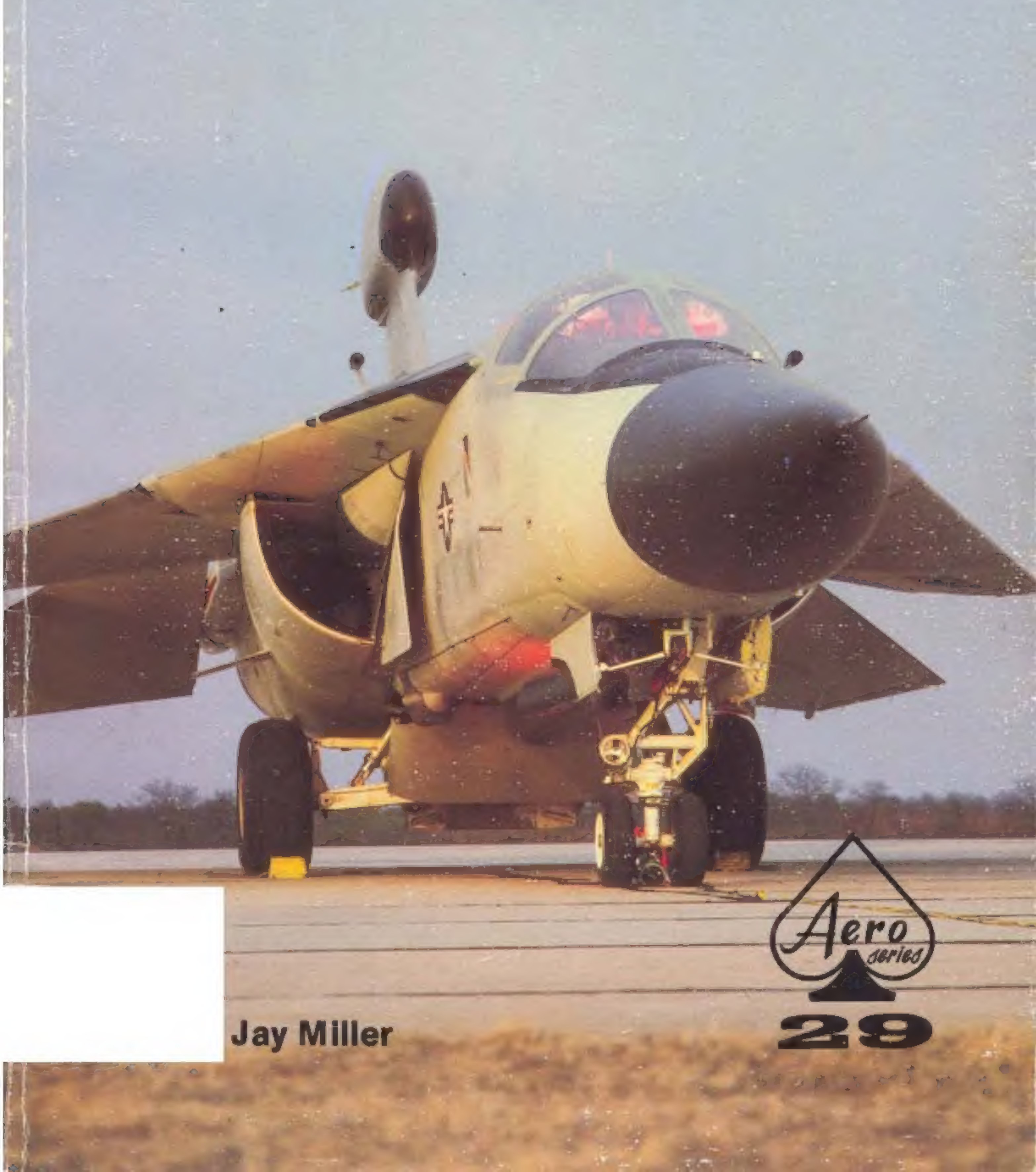
GENERAL DYNAMICS F-111



Jay Miller

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GENERAL DYNAMICS

F-111

by

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Dedicated to Aardvark Drivers Everywhere!

PREFACE

The "Aardvark," as General Dynamics' awesome variable-sweep-wing F-111 is sometimes mischievously called by its more intimate proponents, is unquestionably the most controversial operational warplane of our time. Politically sensitive, economically catastrophic, and mechanically overwhelming, it was in every respect the most complex and extraordinary flying machine of its day.

The F-111 story is unique—and lengthy. What follows is a synopsis of its genesis, a study of its anatomy, and a review of its service career; what will someday be discovered is its greatness . . .

ACKNOWLEDGMENTS

The problem with an acknowledgment section is that there's never enough room to give the detailed thanks each contributor so very much deserves; and there's rarely an occasion wherein absolutely everyone who has helped is remembered. Additionally, it's frustrating to know that there are hundreds, and possibly even thousands of unacknowledged folks without whose efforts the subject of this small book would never have come to life. Suffice it to say that to all of these people I owe a special thanks—and though I can't make mention of each and every one, their help has not gone unheralded.

There are, of course, those people whose more direct efforts must be acknowledged. Among the many are my close friend and mentor, James Stevenson, whose encouragement led to the birth of this effort; Rob Mack, Director of Public Relations, Joe Thornton, Assistant Director of Public Relations, Bill Williams, in Photography, and secretary Margaret Gamble, all of General Dynamics Fort Worth, Texas Division, who made sure that every request was heeded and that the photo selection was superior; Grover "Ted" Tate, General Dynamics Flight Test Engineer extraordinaire (retired), who contributed F-111 lore; James Wogstad, whose friendship and partnership are model performances; Bill Gunston ("Mr. Prolific"), whose own F-111 effort is a super and very readable reference; Lon Nordeen of McDonnell Douglas, who came through with a last minute request for TFX material; David Anderton, who remains perhaps the premier aerospace writer in the United States, and whose contribution to the TAC part of this story is deeply appreciated; Herb Leventhal, Ph.D., Ben Goldman, Ph.D., George Cockle, and Marty Isham; Susan Miller, whose patience and companionship are eternal wonders; one-year-old Anna Noel Miller, whose lack of patience and exploratory bent are also wonders; and last but not least, Larry and Tehila Miller, whose love and support will last this writer a lifetime.

The Heritage of

The development of a practical variable-geometry wing for operational aircraft remains perhaps the single most important factor in the decision to go ahead with the preliminary programs that eventually culminated in the world's first operational variable-geometry airplane—the General Dynamics F-111.

The advent of the swept wing, first presented to the aerospace world in 1935 by Germany's Adolph Busemann, was perhaps the first sign of a legitimate need for variable-geometry capability. Not only did the swept wing bring with it the distinct advantages of significantly higher cruise and maximum speeds, but also the distinct disadvantages of higher landing and takeoff speeds. Lift coefficients dropped, angles of attack increased, and the end result was a higher speed requirement for remaining airborne.

It was the latter, in fact, that proved to be the swept wing's Achilles' heel. An airplane that flew high and fast was of little use if it couldn't be safely controlled during landing and takeoff.

One cure for the swept wing's inherent afflictions arrived in the early 1940s in the form of the first preliminary variable-geometry (v-g) concepts. Simply stated, v-g offered the best of both worlds: high speed in conventional flight and controllability in low speed flight. With an articulated wing—one that could sweep back and forth in concert with the requirement of the moment—it would be possible to cycle into an unswept configuration for takeoff or landing and, while still airborne, cycle into a swept configuration for optimum cruise and high-speed performance.

First production EF-111A (65-049) takes off from Grumman's Calverton, New York Facility on its maiden flight. Airplane has since been delivered to Air Force for service introduction trials. Grumman photo.

Variable Geometry

Unfortunately, the problems associated with v-g were many. Developing a v-g wing was not just a simple matter of articulation. Center of gravity shifts during sweep were enormous; weight penalties were substantial (an articulated wing and its associated center section were by nature substantially heavier than a conventional fixed spar wing); and the mechanical aspects of remotely powering control surfaces and routing fuel lines from the fuselage to the wings were an absolute nightmare of spaghetti-like high-pressure hydraulic and fuel lines.

Early experiments with sweep-type variable geometry were actually initiated, but not consummated, by the Germans in World War II. Their Messerschmitt P.1101, a fighter prototype—turned—testbed that was destined never to fly, was designed with a three-position ground-adjustable variable-sweep wing. This airplane and its associated variable-sweep wing components and data would eventually be transported to the U.S. where, following a detailed government sponsored inspection, it would pass into the possession of Bell Aircraft Corporation near Niagara Falls, New York.

Bell had been interested in the idea of v-g aircraft for a number of years. Robert Woods, one of the founding members of the company and its key design man, had explored

Messerschmitt P. 1101 shortly after its arrival at the Bell Aircraft Corporation plant near Niagara Falls, New York. Visible just above main landing gear strut is wing pivot hinge. Wing sweep was ground adjustable. Note damage to nose. Bell Aerospace Textron photo.

the potential of v-g and had concluded that it was a viable means of taming the swept wing's otherwise contrary personality.

When the P.1101 arrived at the Bell plant in 1946, Woods and his associates examined the airplane in detail. They soon concluded that it was basically a sound design and one worthy of further development. As the P.1101 had been severely damaged during the course of its trip to Bell, a decision was made not to attempt a rebuild of the available airframe, but instead to proceed with the design and development of a totally new airplane based on the P.1101's airframe and design technology.

Most important was that the proposed new design would incorporate a functioning on-board system for changing the wing sweep angle in flight. Developed by Woods and his engineering staff, this would be the first flightworthy device of its type in the world.

On June 20, 1951, the X-5—as Bell's rendition of the P.1101 was designated—made an uneventful first flight. A second prototype, the only other one built, followed several months later.

Both X-5s soon became involved in a relatively successful and technologically rewarding flight test program. Test operations were conducted from Edwards Air Force Base, California. The first successful translation occurred during the fifth flight of the number one X-5 (50-1838) which took place on July 27, 1951. On this flight, the complex roller-and-rail wing sweep mechanism was cycled for the first time. The translation angles were kept to a minimum, but the test was still considered informative, successful, and historically significant.

Though the X-5 test program spanned several years and was considered unusually constructive, it was also the first to prove that

Bell X-5, world's first successful variable-geometry-capability airplane, shown shortly after roll-out at Bell plant. 50-1838 was prototype. 50-1839 was second airplane in series; 50-1839 was destroyed during a spin test at Edwards AFB, California, on October 14, 1953. Bell Aerospace Textron photo via Jim Wogstad.

In-flight shot of X-5 shows airplane with wings in maximum sweep condition. Bell Aerospace Textron photo.

problems related to variable-geometry aircraft were indeed real. These included discoveries that the complexities and excessive weight penalties of wing sweep mechanisms were not easily overcome; that the problems associated with transonic center of lift changes were deserving of much further exploration; and, most importantly, that the economics of building an operational v-g airplane had yet to be justified.

Another noteworthy v-g program initiated during this early-1950s period was Grumman's bulbous XF10F-1 *Jaguar* fighter. Eventually making its first flight on May 19, 1952 following several years of design development, the XF10F-1 was the result of a program that had begun nearly half a decade earlier. This program had called for the development of an advanced, swept-wing version of the basic F9F *Panther*.

A slow, evolutionary design process had meandered through a large number of configuration studies (including several with variable-*incidence* wings) before settling on the one design that was to become the first v-g airplane in the world designed from the start to fulfill a legitimate operational requirement.

Once it was flown, the XF10F-1's variable-sweep wing proved trouble free. But other technical aspects of the airplane did not. Alas, a general lack of interest in the project, and a strong but conservative concern for over-complexity, cancelled a follow-on F10F production contract in February 1951. This contract had called for the construction of some 82 F10Fs for U.S. Navy service.

Grumman's variable-sweep wing mechanism was a slight improvement over the Bell variation, as it offered a hydraulic (versus Bell's electric) actuation mechanism. Like the Bell design, however, the wings simply translated as they pivoted, in this way compensating for center-of-gravity and center-of-pressure shifts.

This type of translation was not really the ideal solution to the v-g challenge. In fact, as much as anything else, translation of this type—in which the root section of the wing moved backwards and forwards as sweep increased or decreased—was the downfall of these early v-g designs rather than the redemption. Early wing sweeping mechanisms called for extremely complex

Second variable-geometry-capability airplane to fly was Grumman's relatively unknown XF10F-1 Jaguar. Airplane was built to an actual Navy requirement and over 50 were on order at the time of program cancellation. Grumman Corporation photo.

center sections and mechanical solutions to geometry problems that weren't acceptable in an operational environment. Additionally, the weight of the translating wing mechanism, from an airframe standpoint, was simply untenable.

Though Bell and Grumman had involved some of the world's finest aerospace engineering talent in their struggle to conquer the problems associated with variable-sweep wings, it was not until 1958, when NASA's aerodynamicists at Langley Research Center in Hampton, Virginia released their findings concerning the problem, that a legitimate solution was at last in hand.

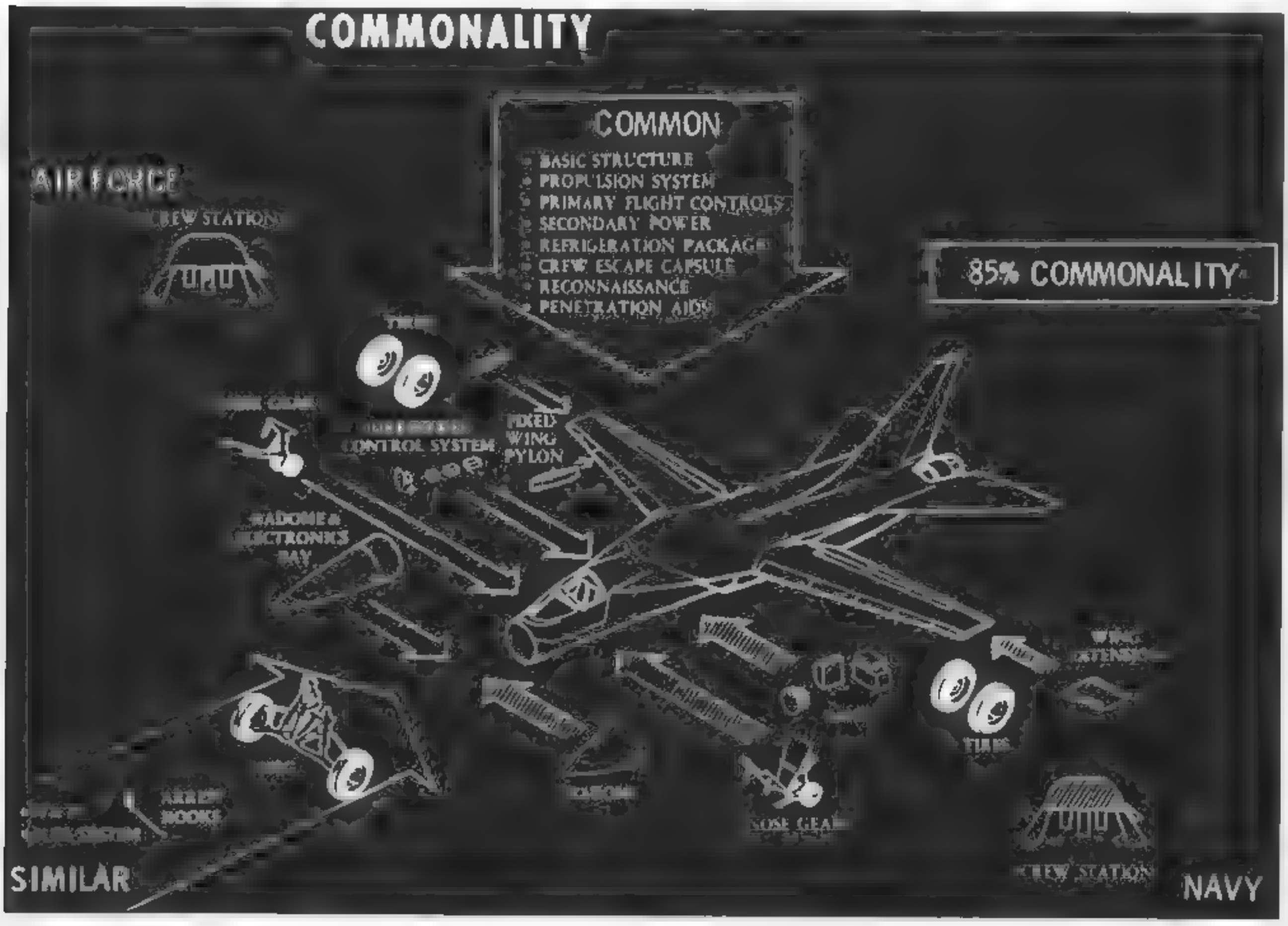
The NASA findings, based on earlier research in Britain, showed that the complications associated with translating wings could be avoided by placing the wing pivot points outboard of the fuselage sides.

Sounds simple? It was. In fact, the revelation brought out by the NASA findings was almost embarrassingly simple—but it worked.

BIRTH OF THE TFX PROGRAM

John Stack was then NASA Langley's assistant director and one of the prime movers behind the programs that gave birth to such unique high-performance research aircraft as the Bell X-1 (which was at one time a candidate for variable-sweep wings, along with its successor, the Bell X-2), the Bell X-2, and the North American X-15. Stack was quick to realize the great potential of the new NASA discovery in relation to tactical military aircraft. Stack was soon in contact with Brig. Gen. Frank Everest, who was then the acting commanding general of the Tactical Air Command.

Almost coincidentally, TAC was just beginning a study calling for the development of a fighter/bomber replacement for Republic's mighty F-105 *Thunderchief*—which was then well into its early production program. As the F-105 was a versatile, albeit somewhat limited weapons delivery vehicle, it was assumed that because a relatively



Commonality was the key word in the birth of the F-111. McNamara assumed that if a common aircraft could be built capable of fulfilling the requirements of both the Air Force and the Navy, a significant savings would result. General Dynamics photo via Jim Wogstad.

Photo of low-speed wind tunnel model of Boeing's TFX entry. Boeing's final submission was its Model 818, which differed from the tunnel model shown. This study, however, maintained the dorsal intake and high flotation landing gear. Model 818 was longer and slimmer than tunnel model and had a canopy/cockpit arrangement similar to that of General Dynamics design. Jim Rotramel photos via Kurt Miska

small number had been procured a replacement would eventually be needed.

Shortly after the meeting between Stack and Everest, Everest called together a group of his top personnel and a group of representatives from the aerospace industry. The objective was to convince them that Stack's and NASA's variable-sweep wing theories had merit and were worthy of further study. Everest had high hopes that the idea of v-g would prove so appealing many members of the group would begin design studies using the new technology.

The result of this meeting was the official release on June 14, 1960 of Specific Operational Requirement (SOR) number 183. SOR 183 eventually became known—somewhat infamously—as the Tactical Fighter Experimental (TFX) program. A number of selected aviation companies were invited to consider the requirement closely.

Concurrently with the Air Force's SOR 183, the Navy embarked on a program to develop a new Fleet Air Defense Fighter (FADF). Navy commanders had concluded that Navy fighters then in service, such as McDonnell's versatile F-4, would only be effective in the air intercept role through the next decade. Additionally, such state-of-the-art fighters were severely limited in range and payload and tended to operate on the very edge of low-speed controllability when landing or taking off.

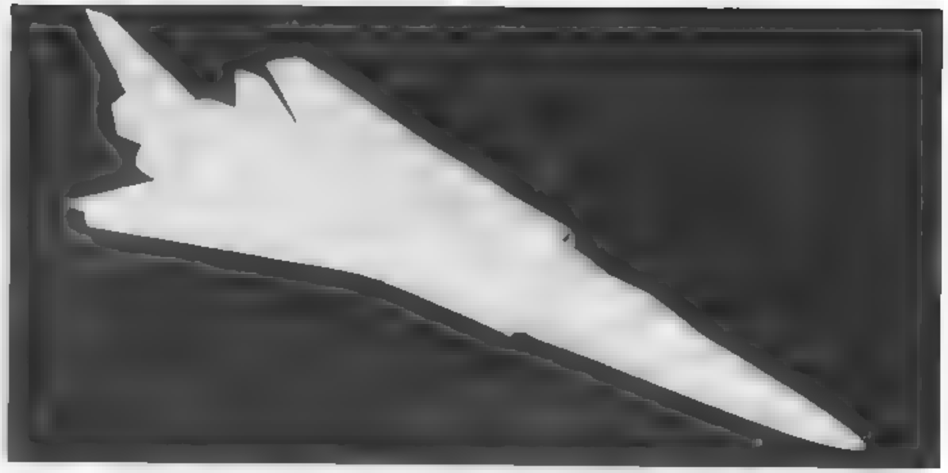
The latter problem was especially critical by 1960. Gross weight and high wing loading figures had crept upward until they could go no higher without a major technological breakthrough in high-lift devices. Variable wing sweep, for some design groups, was the long-sought light at the end of the tunnel.

The Air Force's SOR 183 called for a Mach 1.2 (initially and, as we shall see, importantly, Mach .92) capability on the deck for low-level penetration of heavily defended target areas; an unrefueled transatlantic ferry range; a maximum air-to-air intercept speed of Mach 2.5 at altitude; and the ability to operate from short, unprepared strips.

On the other hand, the Navy's FADF program called for a rather simple yet technologically advanced fighter/interceptor that was carrier-compatible and long-legged.

A collection of some of the early General Dynamics TFX wind tunnel models. Compared here are, from left to right, 10-7A, 9-3A, 500, 1000, and 430. The 500 model depended totally on its horizontal tail surfaces for pitch and roll control when the wings were fully swept. General Dynamics photo.

The 1000 model was the immediate predecessor to what eventually became General Dynamics' final F-111 design study. General Dynamics photo



View of the original 10-7 study. This design followed the 1000 study and led to the final F-111 configuration. Note that the intakes were still rather conventional at this point and mounted ahead of the wing leading edge—rather than under it. General Dynamics photo.

This rare photo illustrates just a few of the many hundreds of models that were built to explore the various TFX program design possibilities. Many of these models were for demonstration purposes only, but others were complex metal models created for use in the wind tunnel. Visible near center background is a study with the intakes located at the wingroot section. General Dynamics photo.

Also specified was that the FADF carry a big, long-range radar and a heavy compliment of air-to-air and air-to-surface missiles.

With the release of these two service requirements to the aerospace community came a new Secretary of Defense appointed by President Kennedy. Robert McNamara, Kennedy's man of choice, took over his new post on January 20, 1961.

Brilliant in the whys and hows of theoretical economics and business management, McNamara assumed that his expertise, as mandated by his Kennedy appointment, would lead the defense establishment to new plateaus of efficiency and economy. To accomplish his broad-ranging goals McNamara almost immediately embarked on a program to incorporate procurement commonality into the defense community.

In a very short time McNamara zeroed in on the Air Force and Navy fighter programs then underway and concluded that they were particularly ripe subjects for his new commonality approach. Accordingly, he called a meeting of top Navy and Air Force officers and met with Dr. Harold Brown, his Director of Defense Research and Engineering. Following this, a team of Defense Department engineers was assigned the task of determining the feasibility of the program.

Their conclusion? Much to the consternation of the Air Force and Navy reps (who had at first taken the proposed bi-service fighter as a half-serious gesture), the McNamara men determined that an Air Force/Navy fighter was not only feasible but well within the engineering state of the art. Most importantly, such an airplane would very likely save taxpayers millions upon millions of dollars.

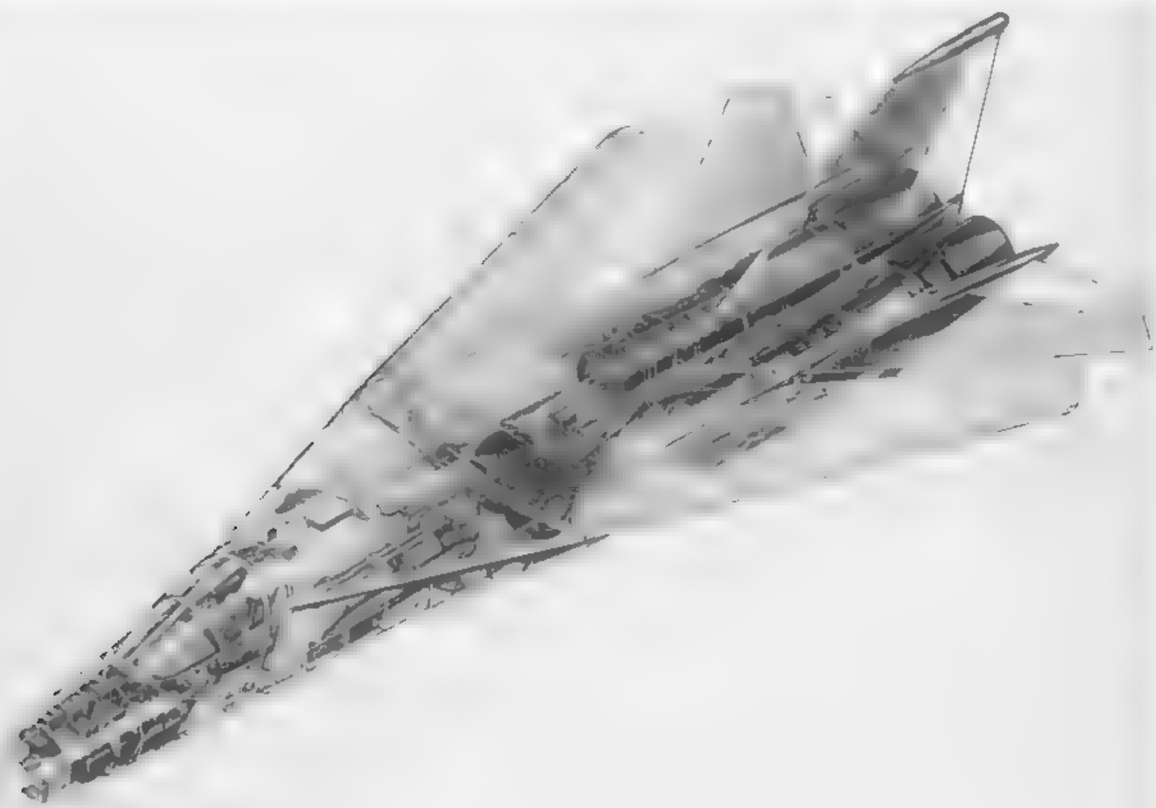
By now McNamara was convinced that his new program had every chance of success. He pushed for congressional approval and also told the Air Force and Navy on February 14, 1961 to consider the proposed multi-service fighter program inevitable and to orient their programs accordingly.

It is interesting to note that during the shuffle that followed, the Navy streamlined its program to make it more compatible with that of the Air Force, and in so doing dropped the requirement that the new fighter be capable of ground support duties. This led to the birth of the VAX (Navy Attack Experimental) program that in turn gave birth to the Vought A-7 *Corsair II*.

Throughout the spring and summer of 1961, the Air Force and Navy battled over the specifications and requirements that would dictate the shape and capabilities of the new airplane. Each service felt that its own mission needs should be given the highest

Rare photo illustrating, for the first time in any publication, the awesome Republic TFX entry. Mock-up was quite impressive. Sweepable portion of wing was much smaller than that of other submissions. Airplane had ramp intakes, two Pratt & Whitney TF30s, and horizontal tail surfaces with downward-canted tips. Republic via Frank Strand collection.

Side-view of the McDonnell Model 156—TFX submission. McDonnell Douglas via Lon Nordeen



Cutaway drawing illustrates internal arrangement of General Dynamics F-111A. Note density of design—there was little room for additional equipment as most of the airplane's internal space was filled. Wing fuel tanks are not shown for clarity. Note avionics bay ahead of crew module. General Dynamics

priority. By fall there had been little if any compromise.

The Air Force was starting to get a bit antsy about the TFX; a go-ahead for an F-105 replacement was desperately needed. The Navy, too, suddenly found itself pushed, as its *Missileer* program, Douglas's F6D standoff air-to-air Eagle missile carrier, had also been cancelled and a replacement would soon be required.

By late October nothing had come of the Air Force/Navy meetings. On September 1, 1961, McNamara made a decision: *he* would personally step in and dictate the specifications for the new airplane.

McNamara's decision was difficult in light of the controversy surrounding the program. Quite literally, he took the bull by the horns and wrestled it to the ground. The new airplane, McNamara decided, would be a fighter/ground-attack type designed around the original Tactical Air Command SOR 183 requirement. Air Force desires would take precedence over those of the Navy and the airplane would heavily favor Air Force specifications and performance criteria.

As mentioned earlier, SOR 183 called for an airplane with a Mach 1.2 capability at sea level. Though at first glance such a requirement might seem relatively unimportant, it was in retrospect perhaps the primary reason for the eventual termination of the entire F-111 program.

The Navy, in their original Fleet Air Defense Fighter requirement, had called for an airplane with a maximum sea level speed capability on the order of Mach .90. The difference between this and the Air Force's request for Mach 1.2 at sea level was numerically insignificant; but in terms of airframe structural requirements it was gargantuan.

An airframe designed for low altitude supersonic flight has to be extraordinarily strong; and in order for it to be strong, it must be very sturdily built. Unfortunately, sturdiness is expensive—not only in terms of increased monetary cost, but also in terms of weight. Moreover, the added weight calls for more powerful engines and bigger engines consume more fuel. More fuel means more weight. It is, as has often been said, a vicious circle.

To meet the low-altitude speed requirement of the Air Force it became necessary for the new bi-service fighter to be both big and, from an airframe standpoint, very dense. All this was okay for the Air Force; but for the Navy, which had every intention of flying the new fighter from its aircraft carriers, it was a disaster.

COMPETITION BEGINS

On October 1, 1961 Requests for Proposal (RFP) were delivered to the majority of the large aerospace companies in the U.S. On December 6, six companies responded. These included Boeing, a combination of General Dynamics and Grumman, Lockheed, McDonnel Douglas, North American, and Republic.

It took almost two months for the Air Force and Navy evaluation teams to make a decision, but by early December a report was issued listing the submissions in order of preference: Boeing and General Dynamics/Grumman were the preferred entries. Interestingly enough, none of the submissions proved acceptable, including the top two. Another competition was quickly called for.

Problems outlined by the Air Force/Navy Source Selection Board overseeing the first competition included Boeing's choice of engine (the General Electric MF295, which was strictly a drawing board project at the time and thus considered exceptionally risky); the generally poor choice among all entries of crew emergency escape systems; the generally poor performance estimates at both high and low altitudes among all entries; and the limited loiter capability of all entries.

The Boeing proposal, even in consideration of its failings, was the top contract contender by the time the second competition got underway in April 1962. This time, the revised submissions were back from the various companies in a matter of weeks. Again, the Board declared them all unacceptable but stated that the submissions from Boeing and General Dynamics/Grumman were viable designs. Boeing's entry, incidentally, had once again been declared best.

The third competition was opened in June 1962. When the further-revised submissions arrived from the two top contenders, it was readily apparent that they had at last met with some success. Both projects were now acceptable in terms of performance and

physical characteristics. The Boeing design was again declared first choice.

FINAL DECISION

The reasons for the Boeing design's superiority centered on the fact that the Boeing submission was the one most easily adaptable to the individual requirements of the respective services. As would soon prove to be the case in the fourth and final competition, this adaptability would also prove to be the design's major failing. Such flexibility was due in part to less commonality among major airframe parts—which in turn *implied* a substantially more expensive airframe.

It was the latter, in fact, that caused McNamara and his independent evaluation team to take matters into their own hands. Following the final review in September 1962, in which the Boeing entry, according to a final Air Force and Navy evaluation, once again came in with top honors, a decision was made to completely reevaluate the criteria used to determine which design was best. McNamara and associates had yet to be convinced that the Boeing airplane was indeed number one.

In fact, they disagreed with the Board's final conclusions enough to completely reverse its decision! On November 24, 1962, the Department of Defense was forced to announce that the bitterly fought TFX competition had been awarded, somewhat mysteriously, to General Dynamics/Grumman

The announcement came as a shock to just about everyone but the Secretary of Defense. Boeing's design had been the preferred airplane from the very beginning, and Air Force and Navy evaluation personnel had been almost unanimous in their opinion that the General Dynamics/Grumman airplane was inferior.

It goes almost without saying that many senators and representatives from the two states directly affected by the competition (Texas and Washington) heatedly argued the merits of the award for several weeks following the DOD announcement. Public and government outcry concerning possible legal infractions finally led to a lengthy and historically important congressional hearing. Chaired by Senator John McClellan, the hearing lasted for weeks and involved the testimony of many key Boeing and General Dynamics/Grumman personnel. Additional testimony was given by Air Force, Navy, and miscellaneous government representatives.

In the end it was declared that no improprieties had been committed and that McNamara and team had every right to make the decision they had made. The controversial DOD contract award was completely legal.

In defending his position during the course of the hearings, McNamara had at last come forth and presented his case to both the government and the people. He supported his decision with many facts and figures and gave a believable question-and-answer performance that left little doubt he felt his decision to be the right one.

In synopsis, the Secretary of Defense had reached his conclusions based on an objective approach to the submitted written proposals of the two competitors. McNamara claimed that he had determined the General Dynamics/Grumman design to be superior when he noted that it was better from an airframe standpoint (this implying a superior fatigue life); that it was better from a performance standpoint (especially in terms of maximum speed capability); that it was better in terms of electronic countermeasures capability; that it had a significantly lower radar cross section; that airframe/engine interface characteristics were better; and that it was better in terms of cost analysis (which harked back to McNamara's original comments concerning Boeing's questionably lower cost estimates in relation to its lower parts commonality factor). Perhaps most importantly, especially from a cost analysis standpoint, the Boeing entry called for thrust reversers (at the miraculously low price of less than $10,000 each!) to meet the specs for landing roll-out requirements. Thrust reversers had not been called for in the original spec and the General Dynamics/Grumman airplane did not have them. Thrust reversers were in McNamara's opinion expensive luxuries (in both initial cost and maintenance costs) for what was to all intents and purposes a decidedly austere airplane.

On the other hand, McNamara was quick to concede that the Boeing design did offer the paper advantages of better ferry range; better loiter capability; and better low speed

Model illustrates the final TFX submission from General Dynamics and the one on which the final contract decision was made by McNamara. Before the first prototype would fly, however, a number of additional refinements would take place—primarily in the intake section and empennage area. Note large size of slab stabilator on this model. General Dynamics photo.

controllability. Additionally, he thought there were distinct advantages to the Boeing design's unique dorsal intake configuration.

The final TFX submissions had come in with total program costs as follows: the General Dynamics/Grumman proposal, the most expensive, was $5,455,500,000. The Boeing proposal, the least expensive, was $5,364,300,000. Note that these figures are in *billions* of dollars, not millions! Both included costs for research, development, test, evaluation, and a given number of initial production machines. At the time, this was the largest single aircraft production contract ever awarded.

On December 21, 1962, General Dynamics/Grumman inked its contract with the Pentagon. The F-111 program was officially and finally underway. The prototype TFX, an Air Force model, was expected to be completed and flown within 24 months.

GESTATION OF A PROTOTYPE

Interestingly, all funds for development of both the Air Force's F-111A and the Navy's F-111B versions were to come from Air Force coffers. The Navy at this point would be required to fund only the development of the Hughes AIM-54 Phoenix air-to-air missile and its associated radar system. At a later date, they would be expected to assume F-111B production funding.

General Dynamics, it should be noted, had teamed with Grumman Corporation based on the latter's extensive experience in designing successful Navy aircraft. Grumman also had a lot of clout with Navy brass, thanks to the success of such outstanding aircraft as the F6F *Hellcat*, the F8F *Bearcat*, the F9F *Panther/Cougar*, and the F11F *Tiger*.

General Dynamics had assigned as many as 6,000 engineers to the F-111 program throughout its development. By the spring of 1963 everything was in high gear and all facets of the airplane's design were being pushed to completion as rapidly and safely as possible.

Due to design requirements that included structural stress capabilities approaching 7.5 gs, a tandem seating two-place cockpit, and physical restrictions that included a maximum length for the Air Force version of no more than 73 feet and a takeoff gross weight for the Navy version of no more than 55,000 pounds, General Dynamics and Grumman found themselves deeply involved in an extraordinarily complex design program. The various technological breakthroughs required were numerous. Included among

Mock-up construction time at General Dynamics. Due to complexity of program and its related bi-service requirements, a number of full-scale mock-ups were built. Three can be seen in this photo Airplane in background is Navy F-111B. General Dynamics photo.

Two views of the Air Force's F-111A mock-up during early mock-up review. Airplane, at this point, was close to being what the Air Force wanted, but still needed some refining. Final intake design decision had yet to be made and the nose configuration still needed work. Additionally, the slab stabilator would undergo several changes and the vertical fin would be shortened and widened. General Dynamics photos.

The final mock-up inspection took place in the fall of 1962. Photo shows the final configuration—which closely resembles the airplane as built. Many changes had taken place by this time, including an improved nose design, a refined intake configuration, and a definitive empennage section. Vertical fin had yet to be reconfigured to production standard. General Dynamics photo.

these was the development of the first operationally configured variable-geometry wing; the incorporation (and development by Pratt & Whitney) of the first operational turbofan engine for fighter use; the development and first use of high-flotation rough field capability landing gear in a fighter; and the development of a large number of miscellaneous systems and parts that ranged from advanced metallurgical techniques to complex fuel transferral plumbing.

The biggest challenge of all was weight. Not only was the Navy airplane particularly susceptible to weight growth, it was controlled in almost all design areas by weight-related considerations. Aircraft carrier deck specifications put an automatic limit to just how much a given airplane could weigh. Every pound was critical. Increased weight directly affected performance.

Original Air Force weight estimates called for an F-111A gross weight of no more than 45,000 pounds. By preliminary mock-up review time this figure had climbed to almost 70,000 pounds! Shockingly, this figure was no less than 15,000 pounds more than the absolute maximum specified by the Navy. Unfortunately, what held true for the Air Force version would almost certainly hold true for the Navy's—only to a much greater extent.

In the midst of the problems associated with phenomenal weight growth, General Dynamics also discovered that their new airplane was not nearly as aerodynamically clean as they had hoped. Over 20,000 hours of expensive wind tunnel time had been logged under the jurisdiction of NASA. Along the way it was discovered that drag curves were significantly higher than predicted. The drag increase was most noticeable in the high supersonic segment of the flight envelope. Problems with intake efficiency, maneuverability, directional stability, and transonic performance were all considered high drag indicators.

On October 16, 1964, following almost two years of design development and construction, the prototype YF-111A, Air Force serial number 63-9768, was officially rolled from the General Dynamics, Fort Worth Division plant doors for the first time. It had been completed some two weeks ahead of schedule.

Following an extensive ground test program that included systems checks and low and high speed taxi runs, this airplane took to the air for the first time on December

21, 1964. Dick Johnson, General Dynamics' chief of flight test, and Val Prahl, another veteran flight test engineer in General Dynamics' stable, were at the controls. The flight lasted only 22 minutes due to a wing flap malfunction and an engine compressor stall at the beginning of the takeoff run. The wings were left in a slightly swept 26-degree setting.

This prototype was more of a testbed than the forerunner of an entire production series. So many new innovations were incorporated into its dense and complex airframe that it was legitimately as much a research vehicle as a pre-production proof-of-concept prototype.

Not only was the F-111 the world's first multi-service, all-purpose, all-weather fighter-bomber, it was also the world's first airplane to incorporate an advanced terrain-following radar and associated low-altitude penetration capability. And it was the world's first airplane designed from the start to have supersonic sea level performance and a range in excess of 3,000 miles.

These capabilities were integrated in one airframe for the first time in the F-111. The variable-sweep wing, as mentioned earlier, had flown only experimentally on two other aircraft; turbofan engines with afterburners had never flown in anything but a wind tunnel; a fully-encapsulated ejection module had never been used on any operational airplane; and terrain-following radar (TFR) was barely into its post-infancy stage.

By the time of the F-111's first flight, the airplane's manufacture had entailed 25 million man-hours and over 21,000 hours of wind tunnel time. Both figures were records for an airplane of the F-111's size and weight.

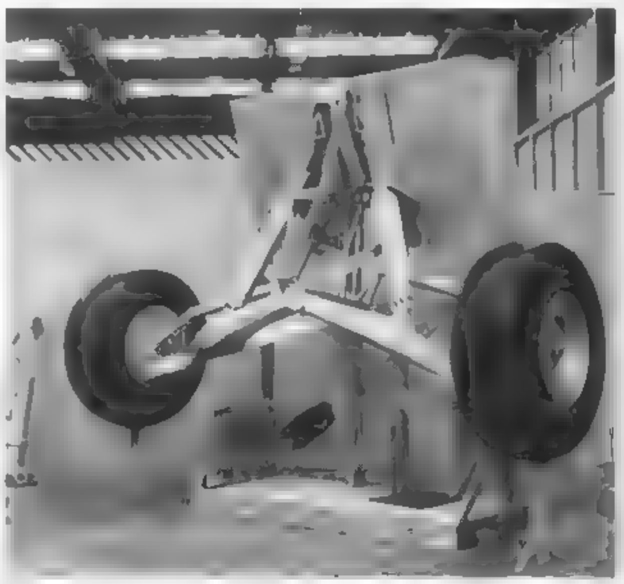
Following the successful completion and evaluation of the first flight, the number one airplane was immediately released for Category I testing. It was during these company-sponsored tests that several items of program-related import came to light for the first time. One, the flight test crews quickly discovered that the F-111 had surprisingly few control vices for an airplane of such advanced design—particularly noteworthy was the variable-sweep wing, which worked according to plan and provided the performance improvements so eagerly sought. Two, it was discovered by maintenance crews that the F-111 was a surprisingly easy airplane to keep flightworthy—paneling gave good accessibility and systems were reliable. And three, it was discovered that the F-111 had a very serious intake design flaw—so serious, in fact, that the maximum obtainable Mach number during the early Category I tests was only 1.3, far below the Mach 2.5 promised by General Dynamics in the original contract.

On February 25, 1965, the second prototype F-111A took to the air and promptly demonstrated the airplane's variable-sweep wing capability. The wings were translated their full range from 16 degrees to 72.5 degrees.

MONEY PROBLEMS

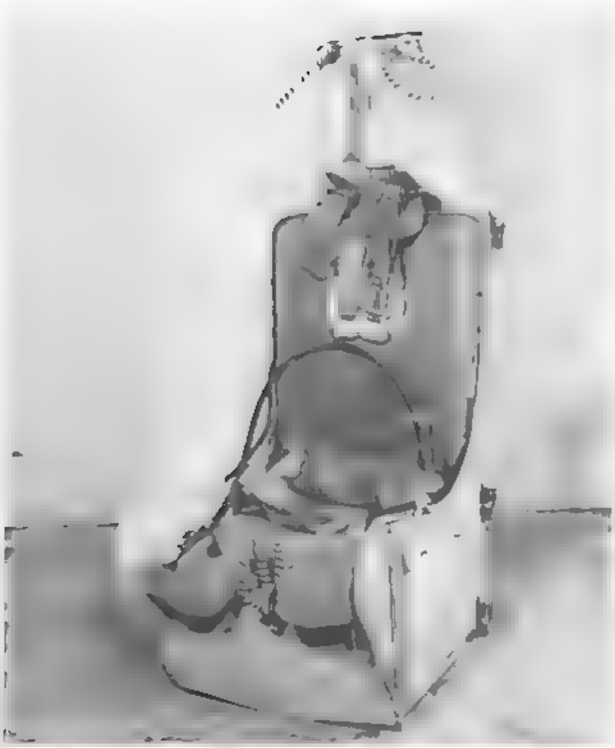
In early 1965, amidst continuing problems with the intake, the powerplants, and much other miscellany, the F-111 was also beset with a major failure of another sort: unit costs were rising at an extraordinary rate.

The program had been designed to be austere. When Secretary of Defense McNamara had first announced the TFX program, he had claimed that a multi-service, multi-purpose fighter-bomber would save the taxpayers millions upon millions of dollars. Unfortunately, these predictions were failing to bear fruit. Within a year following the first flight, unit costs had risen from



F-111 was to be the first production fighter in the world equipped with high-flotation variable-terrain landing gear. Mock-up of original study is shown. Production gear differed only in minor details. Note size of tires and immense shock struts—all for absorbing the loads associated with rough field operation. General Dynamics photo.

Top Left Because of the extreme complexity of the F-111's combat systems a number of dedicated testbed aircraft were utilized to test various F-111 sensors. Among these was the Convair NT-29B show. This airplane was used for radar system tests—primarily in the air-defence mode. The F-111's radar dish occupied the T-29's large nose radome. Top right. A Convair F-106B was also set aside for systems tests In first photo, airplane is shown mounting terrain following radar equipment in nose pod. In second photo, F-111's tail warning sensors are seen mounted in pod above left wingtip. Bottom. Nearly completed fuselage of prototype F-111 is pulled from its jigs and moved to final assembly area Visible in photo is wing center section box with pivot mounts and engine bays. General Dynamics photo



Top. Prototype F-111s were equipped with ejection seats instead of functioning ejection module. Typical seat is shown in photo. General Dynamics photo. Center. The F-111A has an inordinate bomb carrying ability as illustrated by this photo. Airplane has flown on several occasions carrying the load shown (36x250 lbs.). On production aircraft, the outer two pylon attachment points have been declared inoperational and are rarely used in service. General Dynamics photo. Bottom. Lifting off on its first flight, prototype F-111A shows some of the many distinctive features of the breed. Full-span leading and trailing edge devices provided superlative low-speed flying characteristics and permitted near-STOL performance from rough fields. Several problems occurred on first flight, including a compressor stall. The latter was to plague the airplane throughout its service life. General Dynamics photo.

Unofficial roll-out of prototype airplane took place several weeks ahead of schedule. Two views show airplane from ground level and from top of plant building. View from above shows airplane with wings unswept. Prototype color scheme was light grey with white undersides and radome. General Dynamics photos

an original estimate of $4.5 million to $6.03 million.

Though by present-day standards the latter figure seems reasonable enough, in 1965 it wasn't. A public and congressional outcry arose over the increases. Taxpayers screamed en masse, questioning the necessity and viability of an airplane that was not only the most expensive aircraft production program of its day, but also one of the most problem-plagued.

On April 12, 1965, a Letter Contract for 431 F-111s (of several different models) was signed. The aircraft-to-be-procured figure was no less than 50 percent lower than that specified in the original contract!

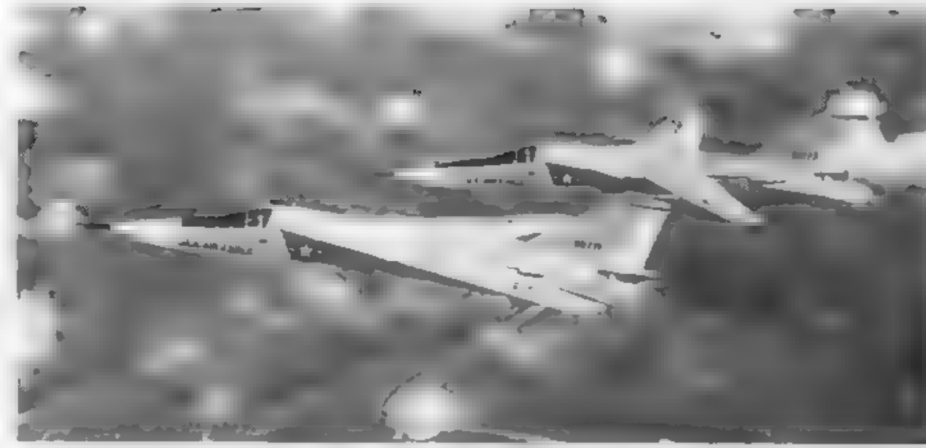
The first F-111 model, the F-111A, was the archetype airframe for the entire F-111 series. All models that succeeded it, from the F-111B through the FB-111A, had similar airframe designs that differed only in relatively minor technical details. Unfortunately, this commonality also led to a carryover of the F-111A's airframe failings, as discussed later.

The prototype F-111A was the first of an initial batch of 23 Research, Development, Test, and Evaluation (RDT&E) aircraft. These airplanes, it was originally proposed, would serve as the F-111 test team and be used to explore all the many characteristics and capabilities of the basic F-111 airframe. It was in this batch of test ships (plus an additional six added later when it was discovered that the initial 23 were not enough) that the F-111's many technical problems were first uncovered. They later served as guinea pigs in the massive effort that went into developing solutions to these problems.

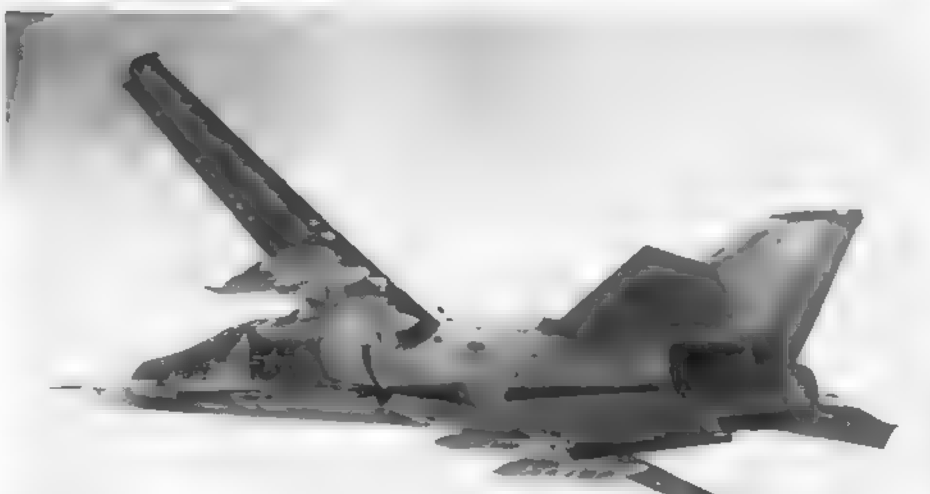
It should be mentioned at this point that General Dynamics and the Pentagon, with McNamara's blessing, agreed to forge ahead full steam with the F-111 production effort. This decision was made many months before the first flight of the prototype airplane. The arrogance of this lay in the fact that the F-111 was a complex and sophisticated aircraft with many new and untried systems. The chances were better than good that there would be problems somewhere. Problems did in fact arise. Unfortunately, by the time they were discovered, explored, and analyzed, many F-111s had already rolled off the General Dynamics production line.

Rather than introduce modifications while the airplanes were still under construction, General Dynamics suddenly discovered that it had to attack F-111 difficulties both on the production line and in the field. The result was a substantially more expensive and logistically more complex modification effort than otherwise would have been entailed.

Such expenses were not easily overlooked in light of their largess. The first major cost increases had amounted to almost $2 million per airplane. By the time the last F-111 rolled out the General Dynamics plant doors, almost ten years after

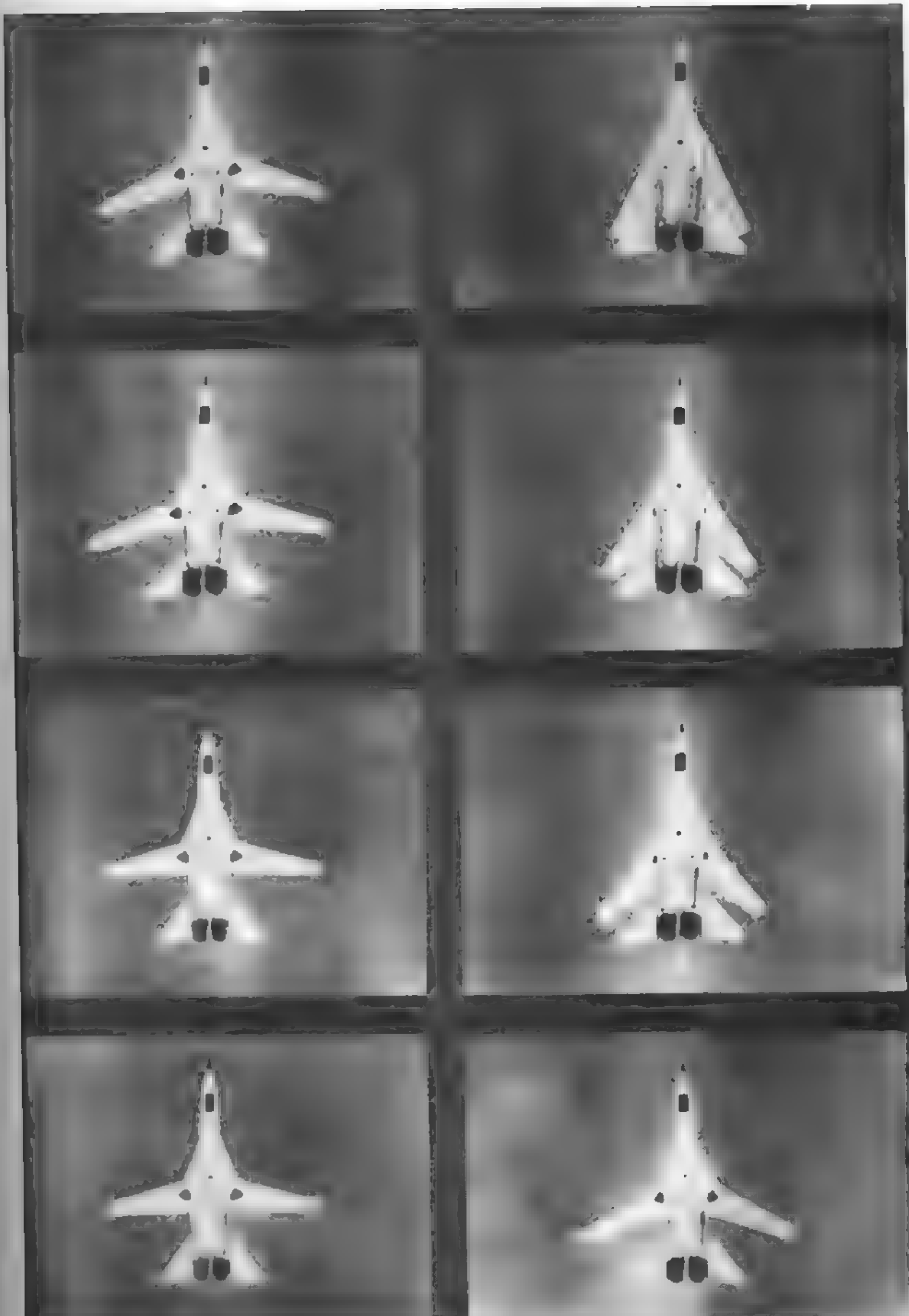


Top left Landing shot of #4 airplane shows to advantage the type's impressive collection of wing high-lift devices. Also readily visible are high-flotation landing gear This particular airplane was devoid of paint throughout much of its early flight test career General Dynamics photo Top right Two of the twenty-plus pre-production F-111A's are shown flying formation over west Texas. Airplane in foregound has wings swept to maximum 72.5°, while airplane in background has wings locked in moderate sweep Sweep angle was infinitely variable Compare angle-of-attack of two aircraft—and note that 63-9771, in the foreground, maintains slightly nose-high attitude. Note also that 63-9771 has unusual tail cone fairing. General Dynamics photo.



In-flight shot of #4 prototype mounting mock-up Phoenix missiles. Note extended leading and trailing edge flaps. General Dynamics photo.

All early pre-production RDT&E F-111s, such as 63-9782 shown, eventually ended their careers at Davis-Monthan AFB, Arizona—where they were temporarily stored and eventually scrapped.



Unusual multiple exposure illustrates the variable wing sweep capability of the F-111. General Dynamics photo

the completion of the first, this figure had increased to nearly $6 million over the original per-unit estimate of $4.5 million!

F-111 MODEL BREAKDOWN

At this point, it is best to change the direction of our story and progress from a slightly different perspective. Before we outline in detail the F-111's basic problems, let's take the airplane, model by model, and relate its specific story—thus giving full coverage to an otherwise complex genealogy.

F-111A. This was the first production F-111 model. The Air Force eventually accepted 158, including 17 updated and improved RDT&E aircraft from the first production batch. The 18th airframe served as the FB-111A testbed (which see). Four RDT&E F-111As were accepted by the Air Force in 1965; eight were accepted in 1966; and five were accepted in 1967. The first five production F-111As were accepted in 1967; 36 followed in 1968; 86 in 1969; and 14 in 1970.

The average cost of an F-111A in then-year dollars was estimated to be $8.2 million. This included $4.3 million for the airframe; $1.35 million for the engines (either Pratt & Whitney TF30-P-1s or TF30-P-3s); $1.69 million for the electronics; $7,000 for the ordnance; and $925,000 for the armament. The estimated cost per flying hour is $1,857.

The F-111A is equipped with both the TF30-P-1 and the TF30-P-3 versions of the basic Pratt & Whitney turbofan engine. The TF30 in this early configuration is rated at 18,500 pounds thrust in afterburner.

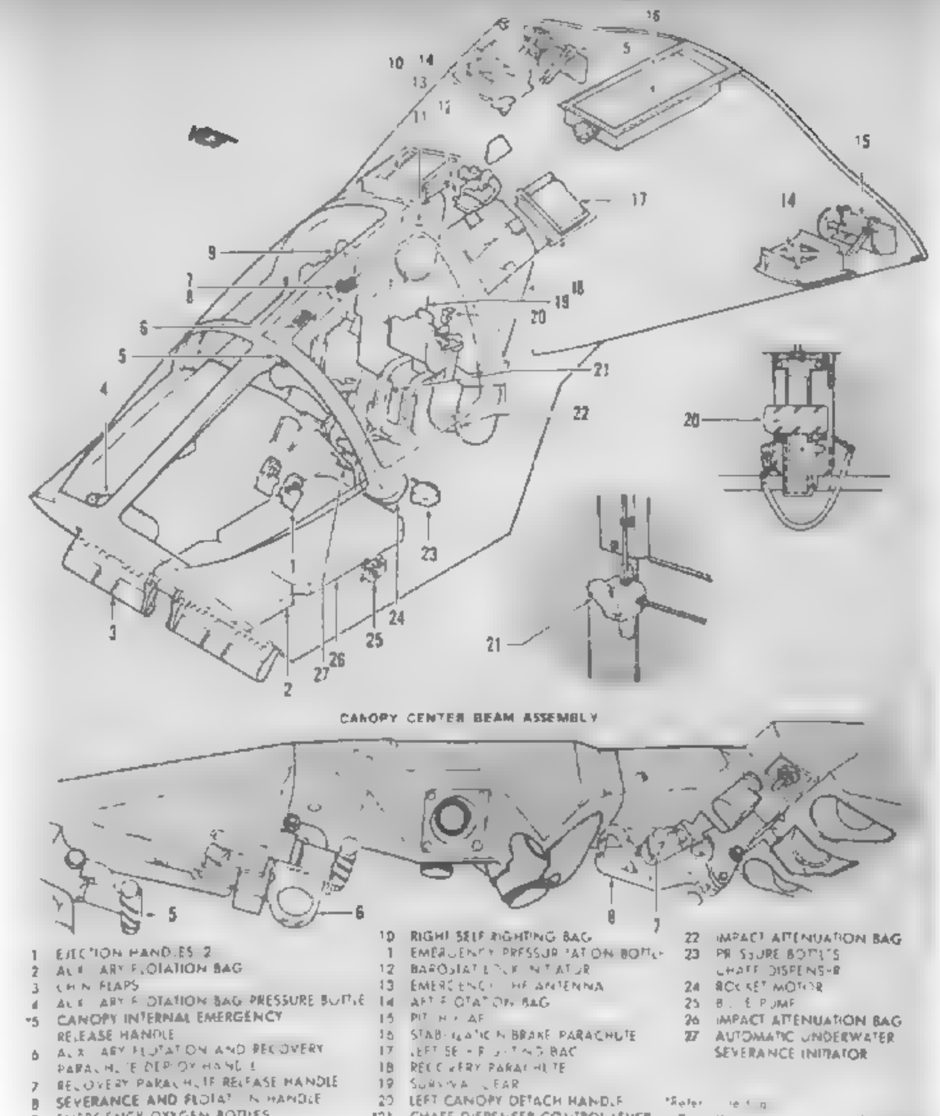
As a point of historical interest, it should be mentioned that an F-111A set an unrefueled nonstop flight endurance record for type of 7 hours and 15 minutes on May 1, 1967. On May 22, two F-111As on their way to the Paris Air Show flew non-stop from Loring Air Force Base, Maine, to Le Bourget Airport, France, in five hours and 54 minutes. They covered the 2,800 nautical miles at an average speed of 540 mph.

Today, F-111As are flown only by the 366th TFW (390th TFS, 391st TFS) and the 57th FWW (433rd FWS). Serial numbers of the airplanes produced are: 63-9766—9783; 65-5701—5710; 66-011—058; 67-032—114.

RF-111A. This was to have been a production variant of the standard F-111A capable of accepting a removable sensor

F-111 has been recalled for modifications and improvements on a number of occasions throughout its career. Nellis AFB based aircraft are shown undergoing wing center section box inspections and repairs in photo. General Dynamics photo

Crew Module General Arrangement

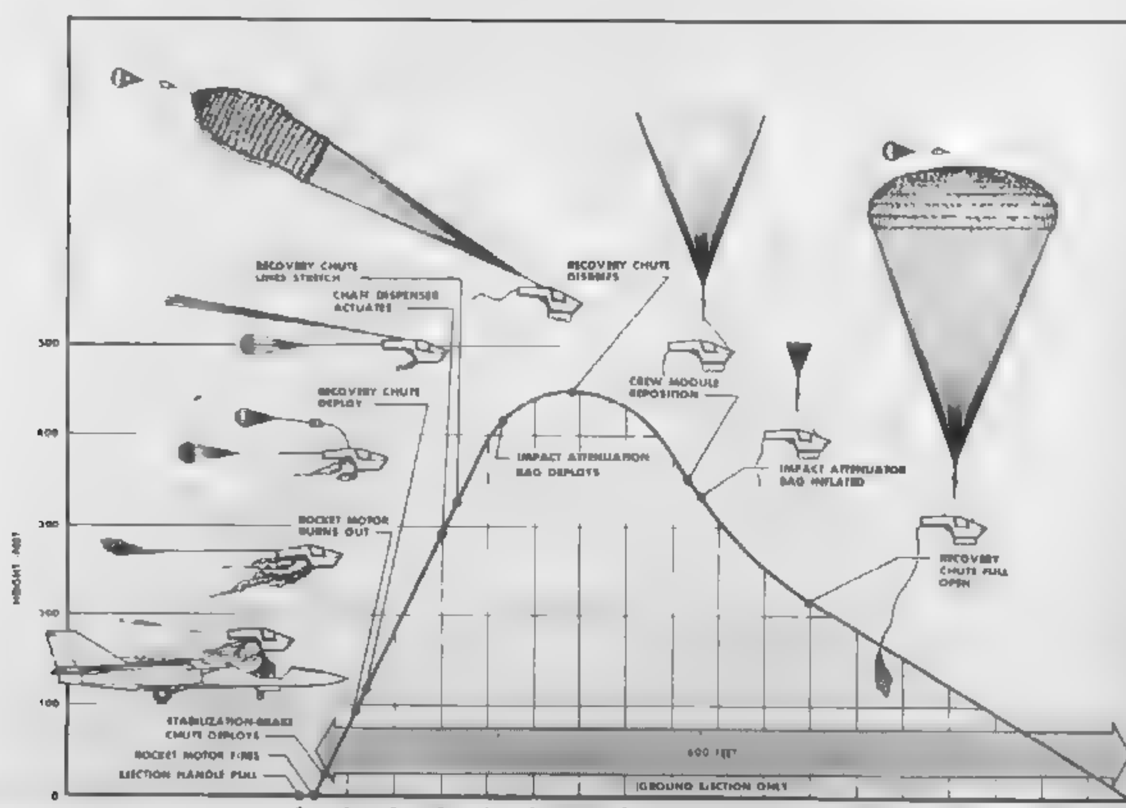


Details of the crew escape module. Not shown are the flotation bags which serve to lessen the shock of landing in the event the module lands on a hard surface; or which serve to keep the module afloat in the event the module lands in water. General Dynamics photo.

View of pilot's side of instrument panel on early prototype F-111A. This particular panel differed significantly from that of production aircraft as it contained little of the equipment associated with the type's various military mission requirements. General Dynamics photo.

Basic ejection module was built by subcontractor and shipped to General Dynamics for completion and installation. Final assembly line is shown at General Dynamics. Note clamshell-type canopy allowing crew ingress and egress. General Dynamics photo.

Crew Module Ejection Sequence



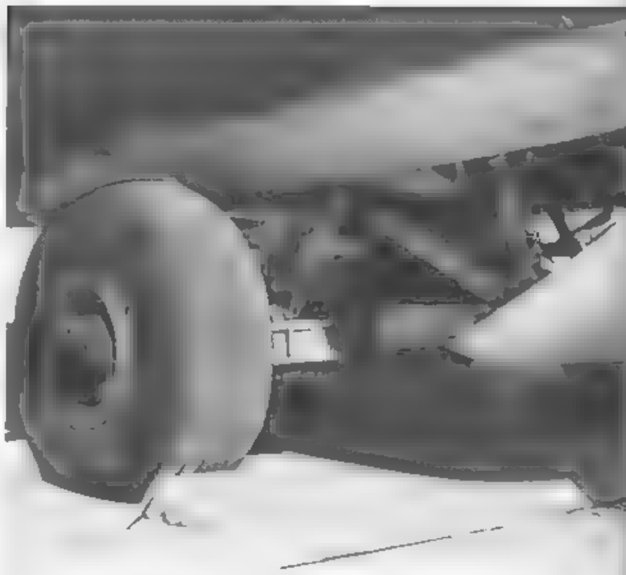
Crew module escape sequence illustration shows what happens when the ejection handles are pulled Note that from module ejection initiation to ground contact, under "zero-zero" conditions, the entire sequence lasts only 18 seconds and covers horizontally only 600 feet. General Dynamics photo.

Fourth prototype F-111A is shown mounting a load of four mock up Phoenix missiles. Though the Phoenix system was scheduled for use by the Navy's F-111B, a decision was made early-on to test the aerodynamics of the missile/F-111 combination on an Air Force airplane. Additionally, there was some Air Force interest in the system at this time. Note this airplane's unusual fuel dump nozzle which can be seen at the extreme tip of the fuselage tail section. General Dynamics photo.

Beautiful inflight shot of Nellis-based F-111A shows airplane with wings swept to maximum 72.5°. In this configuration, airplane is virtually a delta wing design. General Dynamics photo.

pallet in the standard bomb bay. One prototype F-111A, Air Force serial number 63-9776, was modified to RF-111A standards. This airplane was flight tested between December of 1967 and October of 1968. Though results were good, production plans were terminated due to the ever-increasing costs of the overall F-111 program. Additionally, the conversion process from stock F-111A to RF-111A was not as simple as was originally hoped. General Dynamics had promised that a conversion could be completed in a matter of hours. Unfortunately, it actually took days.

At a later date, the Air Force tried to revive the RF-111 program with an updated sensor package and the use of the F-111D airframe. This combination, known as the RF-111D, was aborted in September 1969 due to its high cost and the general scarcity of new-program funds.



High-flotatioin landing gear of F-111 is somewhat complex, yet amazingly rugged. Note low pressure tires for good rough field operation. Visible is large airbrake/gear well cover. Author's collection.

EF-111A. To be discussed separately.

F-111B. To be discussed separately.

F-111C. In June of 1964, the United States and Australia signed an agreement in which the former was to sell 24 F-111As to the latter. These aircraft would not be conventional F-111As, however, and were even-

FB-111A is one of several aircraft in the USAF inventory with Boeing Short Range Attack Missile (SRAM) capability. In photo, early test FB-111A is shown carrying four SRAM test samples. General Dynamics photo

tually given the F-111C designation to distinguish their changes. Among these were FB-111A long-span wings and substantially beefed-up landing gear for improved rough-field performance.

It was to be almost ten years before the last of the 24 F-111Cs ordered was turned over to the RAAF. The cause of this rather lengthy delay was actually a combination of several major events, not the least of which was a wing-carry-through-structure problem (affecting all F-111s) and the redesign of the early F-111A intake configuration.

Australia insisted on receiving pristine aircraft and procrastinated on consummating its contractual agreement with General Dynamics and the U.S. government until all terms were met. Interestingly, the first airplane was delivered on September 6, 1968—with no further deliveries until almost a year later!

The last of the F-111Cs ordered, a group of six airplanes, left the U.S. for Australia on November 26, 1973. Like their predecessor F-111Cs, these airplanes were ferried by Australian crews from Fort Worth, Texas to McClellan Air Force Base. Between four and six training missions were flown at McClellan and the aircraft were then ferried on to Australia.

Four of these Australian ships were destined to return eventually to the U.S. In 1978 a decision was made to convert them to photo reconnaissance platforms, equipping them with a special sensor pallet mounted in the internal weapons bay. This conversion program was undertaken and completed in late 1979 and early 1980.

The F-111Cs were assigned to RAAF 1 and 6 Squadrons. The USAF serial numbers are: 67-125—67-148.

F-111D. Though alphabetically the fourth F-111 model in the program, the F-111D was actually the fifth in that it followed the F-111E on the production line (see the F-111E section). The F-111D incorporated the Triple Plow II intake modification, an avionics system referred to as the Mk.II, an improved environmental control system, and the TF30-P-9 engine rated at 19,600 pounds thrust.

Basically, the Mk.II mod was perhaps the most important of the many changes embodied in the F-111D. This system was designed to control, in any weather situation, the accurate release of various air-to-air missile types against both high and low altitude targets.

The Mk.II system was built by North American Rockwell's Autonetics Division. Its improved air-to-air capability was a product of its AN/APQ-130 attack radar which could operate in heavy ground clutter and provide a narrow, continuous search beam for semiactive radar-homing air-to-air missiles (as it turns out, this capability has rarely been used). Tied in with the advanced Autonetics unit was a digital computer known as the AN/AYK-6. This unit was a significant improvement over the somewhat limited capability of the analog computer used in the F-111A and the F-111E.

Additional F-111D differences delineating it from its stablemates included an AN/APN-189 doppler navigation radar, FB-111A tires on all landing gear units, and FB-111A landing gear axles, axle pins, stabilizer rods, nuts, and attachment pins.

In operational service, the F-111D's standard armament consists of AIM-9 Sidewinder missiles and a General Electric 20mm M-61A-1 rotary gun (mounted on the right, inside the fuselage weapon bay).

The first F-111D—and the only one for the following 12 months—was accepted by the Air Force on June 30, 1970. Within weeks of its delivery it became apparent that the airplane suffered from a number of avionics-related problems. By June 1972 only 24 F-111s had been delivered out of a total of 96 ordered. (The original order was for 315 aircraft, but due to the Mk.II problems this was significantly trimmed.)

The F-111D first entered operational service with the 27th TFW (481st TFS, 522nd TFS, 523rd TFS, 524th TFS) at Cannon Air Force Base, New Mexico on November 1, 1971. Eventually, the 96 aircraft on order were delivered, although the last of these was not turned over until February 28, 1973.

Due to its extremely advanced avionics system—in some respects it was considered ahead of the production state of the art—the F-111D proved to be perhaps the most problem-plagued of the several F-111 variants. The problems of the Mk.II system were never completely rectified, and in fact, as of mid-1980 were still the cause of an F-111D operational availability rate of less than 30 percent.

Part of the F-111D's problem has also been caused by a simple lack of spare parts. Unfortunately, this problem, basically financial in nature, remains unsolved and the entire F-111D fleet is periodically grounded because of it.

The F-111D cost an average of $8.5 million per airplane. This included $3,895,000 for the airframe; $1,229,000 for the engines; $2,530,000 for the electronics; $6,000 for the ordnance; and $844,000 for the armament. F-111D Air Force serial numbers include: 67-115—124; 68-001—084.

F-111E. This was, technically speaking, simply an improved F-111A. The F-111E was basically a standard F-111A with Triple Plow II intakes, an improved stores management set, and other minor modifications.

In truth, the F-111E was an interim development evolved to fill the gap left by the extraordinarily slow development of the aforementioned F-111D. Without incorporating the advanced Mk.II avionics system, the F-111E was designed to temporarily take on the tactical support duties originally intended for the D.

The first airplane in the F-111E series flew for the first time on August 20, 1969, and was shortly afterwards turned over to the 27th TFW at Cannon Air Force Base. The airplane was declared operational less than a month later. By December, 29 F-111Es had been delivered to the 27th.

Unfortunately, the loss of an F-111 during that month caused the type (along with all other F-111 models) to be operated on a restricted basis for some six months following service introduction. Inspections led to a slow lifting of restrictions. By September 1970 full performance missions were again being flown.

It was also in September that the F-111E was sent overseas for the first time. On September 11th, the first of 79 F-111Es scheduled for operations with USAFE arrived in England to join the 20th TFW. Just over a year later, the unit was declared fully operational.

Unfortunately, the F-111E suffered from many of its predecessors' problems. Included among these was a malfunction in the escape module recovery chute system and a deficiency in the windscreen design. The latter caused the loss of several aircraft following bird strikes. Improvements in the windscreen design were many months in coming due to difficulties related to the high speed bird strike requirement.

Besides the 20th TFW, the F-111E also serves with the 57th TTW (433rd FWS). Air Force serial numbers include: 67-115—124 and 68-001—084. A total of 94 were built.

F-111F. This was perhaps the definitive model of the entire F-111 series. It combined all the good features of the basic Mk.II avionics package (sometimes referred to as the Mk.IIF for the F-111F, and consisting of the F-111D and FB-111A navigation and digital computer systems), the AN/APQ-144 attack radar of the FB-111A, the stores management set of the F-111E, improved landing gear, an improved wing carry-through box, and the substantially more powerful TF30-P-100. The result was a weapons delivery vehicle that remains one of the most outstanding aircraft of its type in the world today.

The F-111F was first included in the Air Force acquisition budget during the 1970 fiscal year. Production was okayed on June 19, 1970, and the definitive contract, for 24 production aircraft, was signed on July 1.

Development of the advanced P-100 engine had come in early 1968 when the Air Force concluded that available TF30 variants were not powerful enough to compensate for the massive weight increases the F-111 was incurring. Originally intended to power late production series F-111Ds, the engine was eventually approved only for the F-111F

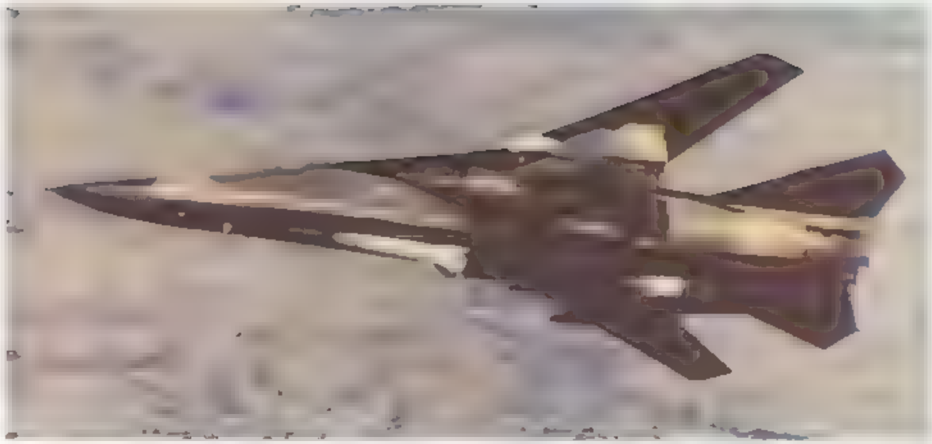
Introduction of the P-100 was some time in coming, due in part to a number of significant engine failures on the Pratt & Whitney test stand. While these problems were being worked out, a decision was made to complete all F-111Fs as necessary using the older TF30-P-9 engine. Once problems with the P-100 were corrected, all F-111s built or under construction were retrofitted.

On September 20, 1971, the 347th TFW became the first unit to go into operational service with the F-111F. Four months later, the type reached initial operational capability.

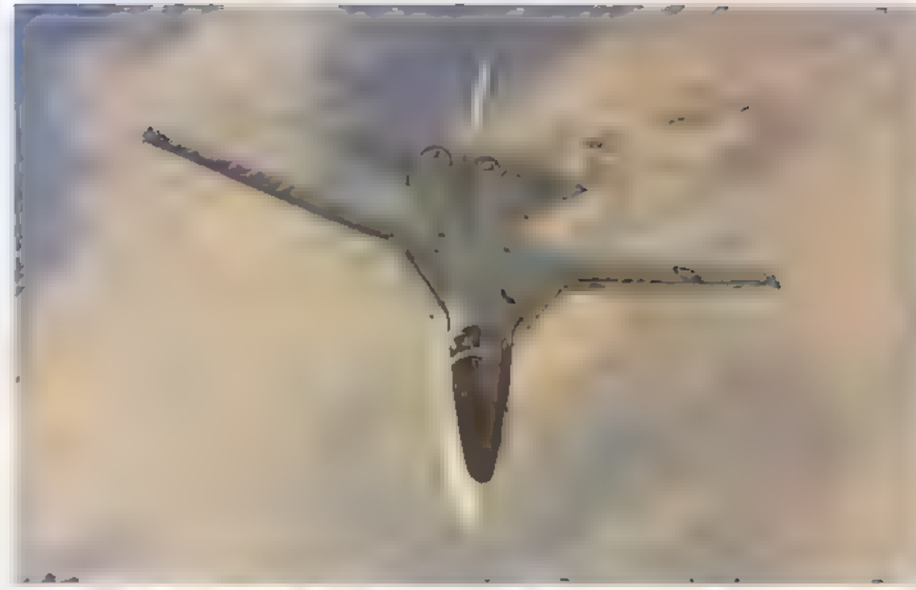
All was not rosy for the F-111F during its first year of service. The P-100 proved to be somewhat troublesome and, in fact, suffered from a rather severe afterburner stall

Rare color photo of RF-111A Prototype.

Prototype FB-111A demonstrates external tank carrying ability for extremely long range non-stop missions. Production aircraft have rarely utilized the outboard pylon option. General Dynamics photo.



Unusual air-to-air photo shows F-111E mounting a Pave Tack unit, a GBU-15 CWW, and a GBU-15 data link pod. The GBU-15 is a modular guided weapon capable of CEP's at 20 miles of less than 30 inches. Pave Tack is a laser designating unit. The data link pod permits communication with the GBU-15 during its flight to the target. General Dynamics photo.



Pre-production F-111A poses for photographs at high altitude.

F-111 has suffered from serious drag problem throughout its career. Much of this drag is created in the tail area of the airplane 63-9771, in photo, is shown mounting unusual tail cone fairing that, it was hoped, might alleviate some of the drag problem. Unfortunately, it did not. General Dynamics photo.

Bomb carrying ability of F-111A is extraordinary. This test flight shot illustrates an early F-111A pre-production airplane carrying no less than twenty-four 500 pounders. Wings could not be swept with this payload in place! General Dynamics photo.

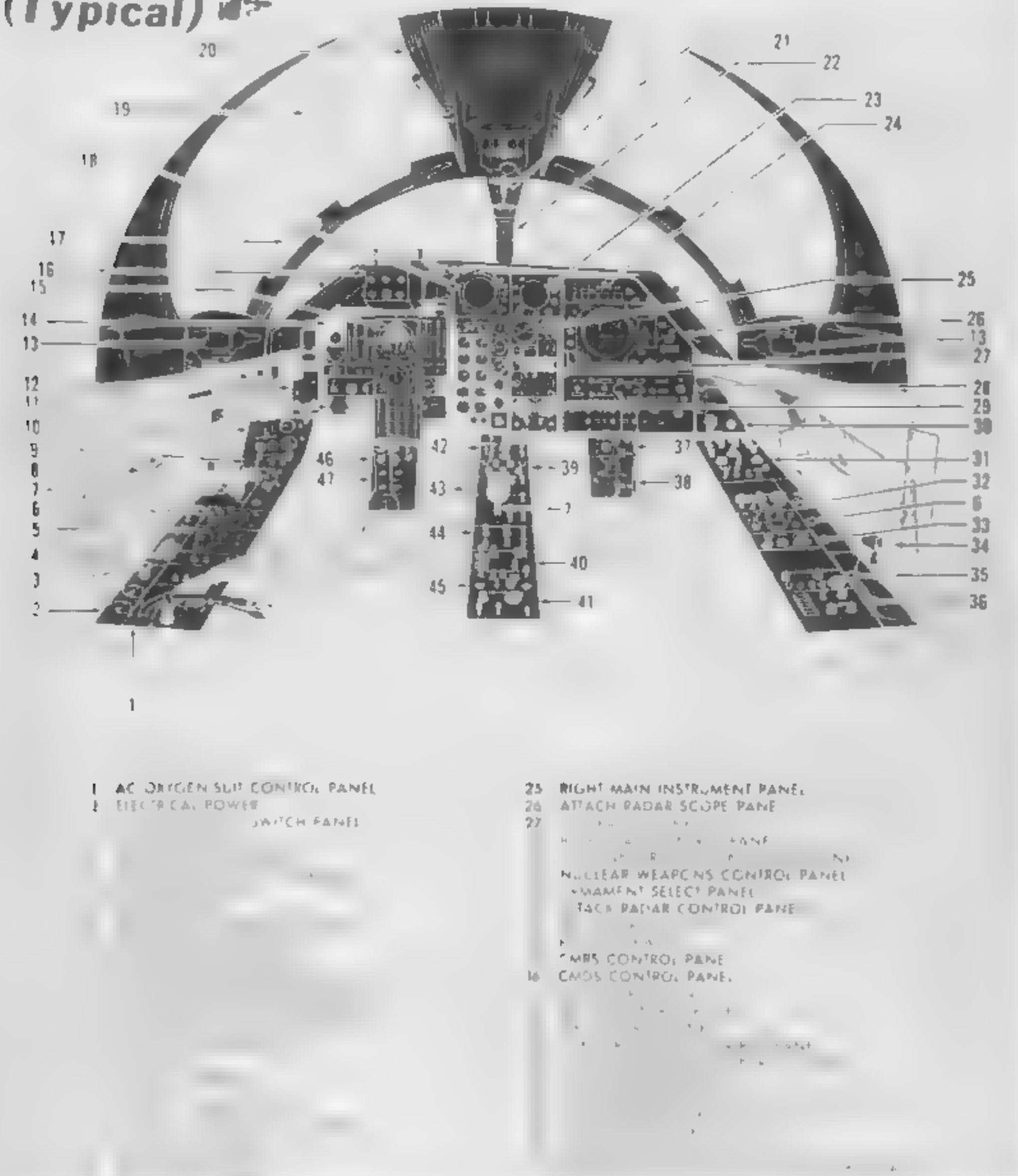
Sporting their unique camouflage, two FB-111As head for home following training mission. Standard two-drop-tank-mission-configuration is once again illustrated. General Dynamics photo.

Early test flight of prototype F-111A shows airplane with wings in fully swept position. Airplane was extraordinarily clean in this configuration. General Dynamics photo.
Rare color photo of RE-111A prototype.

Rare photo of early production F-111A, 66-057 in all-white markings. Airplane was used for various performance tests and was painted white for visibility purposes. General Dynamics photo.

Unusual photo of second prototype F-111A shows airplane in bare metal scheme with white radome Photo taken at Edwards AFB in May of 1965, shortly after beginning of flight test program. Al Hansen photo.

Crew Station General Arrangement (Typical)



Typical F-111A cockpit is shown in this illustration from the pilot's handbook. Note that the co-pilot position is given armament system responsibility. General Dynamics photo

The F-111 is capable of carrying a variety of weapons. Free falling thermonuclear bombs, like the Mk.61 weapon shown, are periodically carried if the mission objectives require them. General Dynamics photo

problem that was many months in being cured.

The last F-111F of the 106 eventually delivered also proved to be the last F-111 built. This airplane was completed by General Dynamics in 1976 and delivered to the Air Force shortly afterward.

The F-111F had an estimated per-aircraft cost of $10.3 million. This included $5,097,000 for the airframe; $2,026,000 for the engines; $1,711,000 for the electronics; $6,000 for the ordnance; and $1,529,000 for the armament.

This type, following introductory service with the 347th, was eventually to serve with the 366th TFW, the 48th TFW, and the 57th TTW (433rd FWS). Air Force serial numbers are: 70-2362–2419; 71-883–894; 72-1441–1452; 73-0707–0718; 74-0177–0188.

FB-111A. This was the only major modification of the basic F-111 airframe to be placed in production. The FB-111A incorporated a number of changes including a 2-foot 1-inch fuselage extension (75'6" for the FB-111A versus 73'6" for the F-111A); a wingspan extended by 7 feet; a much more robust landing gear (to handle the increased gross weights); larger and more numerous fuel tanks; and TF30-P-7 engines.

To accomplish its weapons delivery objectives the FB-111A also had a Mk.IIB avionics system. This consisted of an improved F-111A attack radar, an inertial navigation system, digital computers, and advanced cockpit displays. The unit was specially designed to control the FB-111A's armament—primarily Boeing's AGM-69A Short Range Attack Missile (SRAM) and a variety of free-falling nuclear weapons.

Birth of the FB-111A program can be attributed to the now defunct Advanced Manned Strategic Aircraft (AMSA) program. General Dynamics, during the course of the AMSA competition, had been working on a small bomber version of the F-111 for a number of years. When confronted with the possibility of a legitimate Air Force interest, the company promptly presented two basic concept studies for consideration. This took place in November 1963.

Funding for further research was received by General Dynamics several months later. This included enough money to initiate a series of representative wind tunnel tests. By spring 1965 these had been completed with favorable results.

On June 2, 1965, the Air Force decided to order an austere version of the bomber F-111. This order was formally approved on December 10, 1965, when McNamara publicly announced the program for the first time.

Funding problems delayed official action on the order until February of 1966. It was not until the following May, however, that the actual contract was finally signed. Further delays followed, caused in part by McNamara's insistence that a more sophisticated avionics package be included. Finally, on July 31, 1967, the first of two prototype FB-111As, the 18th RDT&E F-111A highly modified, took to the air for the first time. This airplane had not been completely reconfigured to FB-111A standards as it still had stock F-111A landing gear and the original P-1 engines.

Original FB-111A engine plans called for a modified version of the Navy's new TF30-P-12 (to power the F-111B). This engine was still under development at the time of the FB-111A's birth and, accordingly, was somewhat of an unknown quantity when the FB-111A contract was signed.

The Air Force went ahead with its decision to buy the P-12. However, it insisted that a substantial number of serious modifications be incorporated. Not the least of these was the addition of an afterburner section mod known as the semi-actuator ejector (SAE) nozzle.

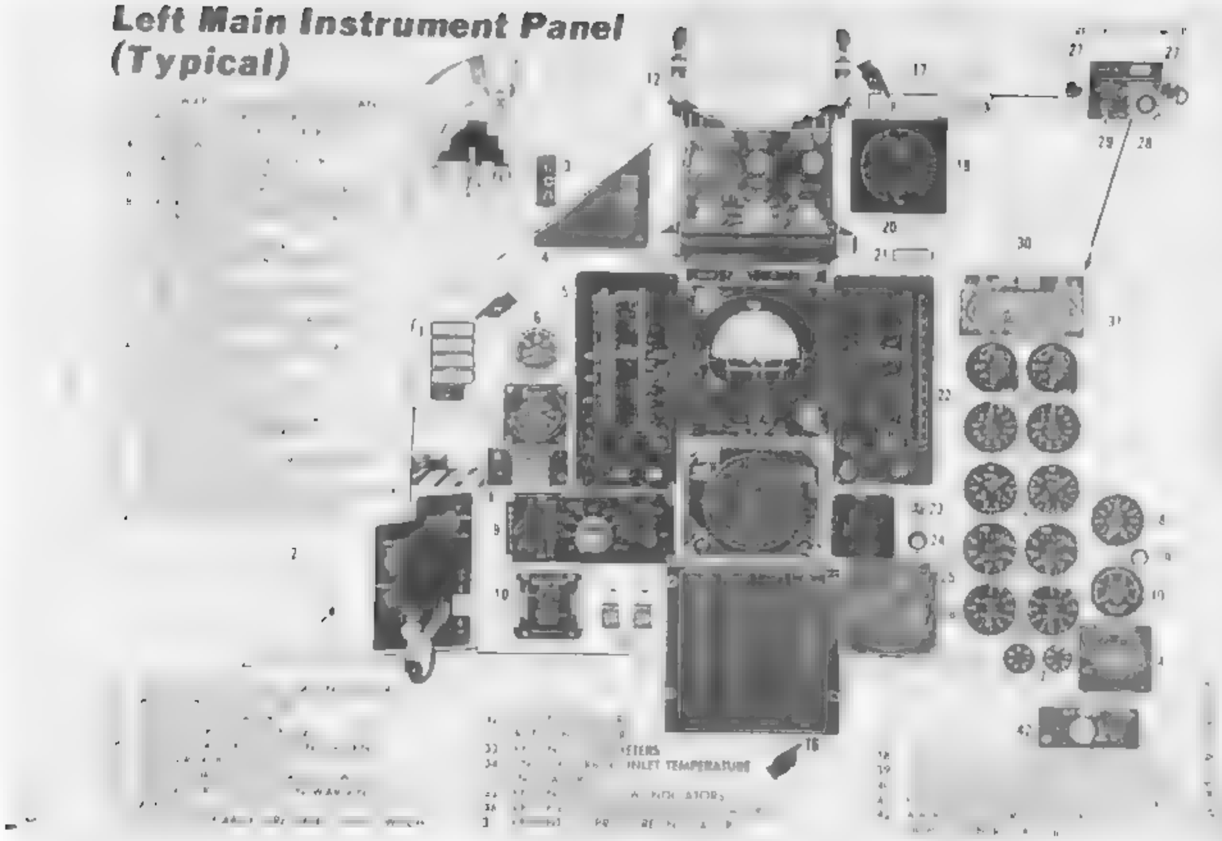
This addition led to a new P-5 model designation (for the Air Force version). Unfortunately, development of the P-5 was eventually halted before a single airplane could be completed. Cancellation was brought on by difficulties with the SAE nozzle—and, as usual, by escalating cost. In place of the P-5, the Air Force selected the P-7. This engine offered some of the P-5's attributes and did away with the impressive SAE nozzle.

Due to the rushed nature of the FB-111A program, the first production aircraft were completed with stock Navy P-12 engines. These were later updated to P-7 standard; some 43 engines were affected in all. The first production standard FB-111A flew for the first time on July 13, 1968. Unfortunately, problems with the advanced avionics system

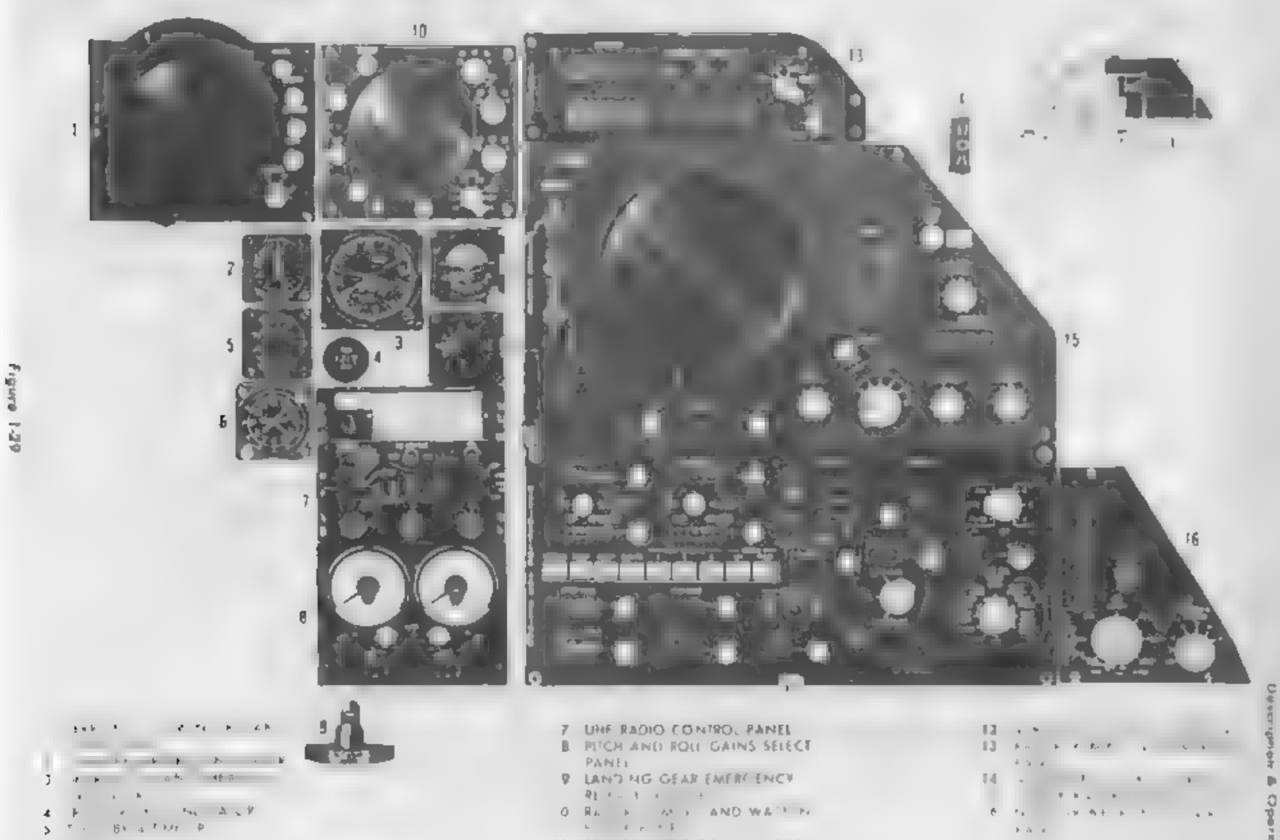
ALQ-87 electronic countermeasures pod is a modular unit adaptable for use in a variety of scenarios and combat situations. It is shown hanging from a pylon under the aft engine bay section of an F-111A, between the airplane's twin ventral fins. Author's collection.

This particular FB-111A has won a number of major bombing competitions. Visible on the nose landing gear door are symbols for five Fairchild Trophies—indicating at least five major victories. Note also deployed inflight refueling receptacle just above wing root section. Author's collection.

Left Main Instrument Panel (Typical)



Right Main Instrument Panel



Instrument panels in the F-111A showing the weapons systems controlled from the left seat. General Dynamics photos.

delayed further deliveries for almost eight months

Eventually, the first seven FB-111As were used in the type test program. This proved to be a lengthy undertaking, as Category II and Category III tests were not completed until mid-1972, some four years after the tests began.

The original early-1968 FB-111A program called for the production of 263 aircraft. This figure was cut to 126 by November, and to 76 in March of 1969. These cutbacks were brought on by increased program costs, uncertainties related to the airplane's capability, and technical problems related to its engines and avionics.

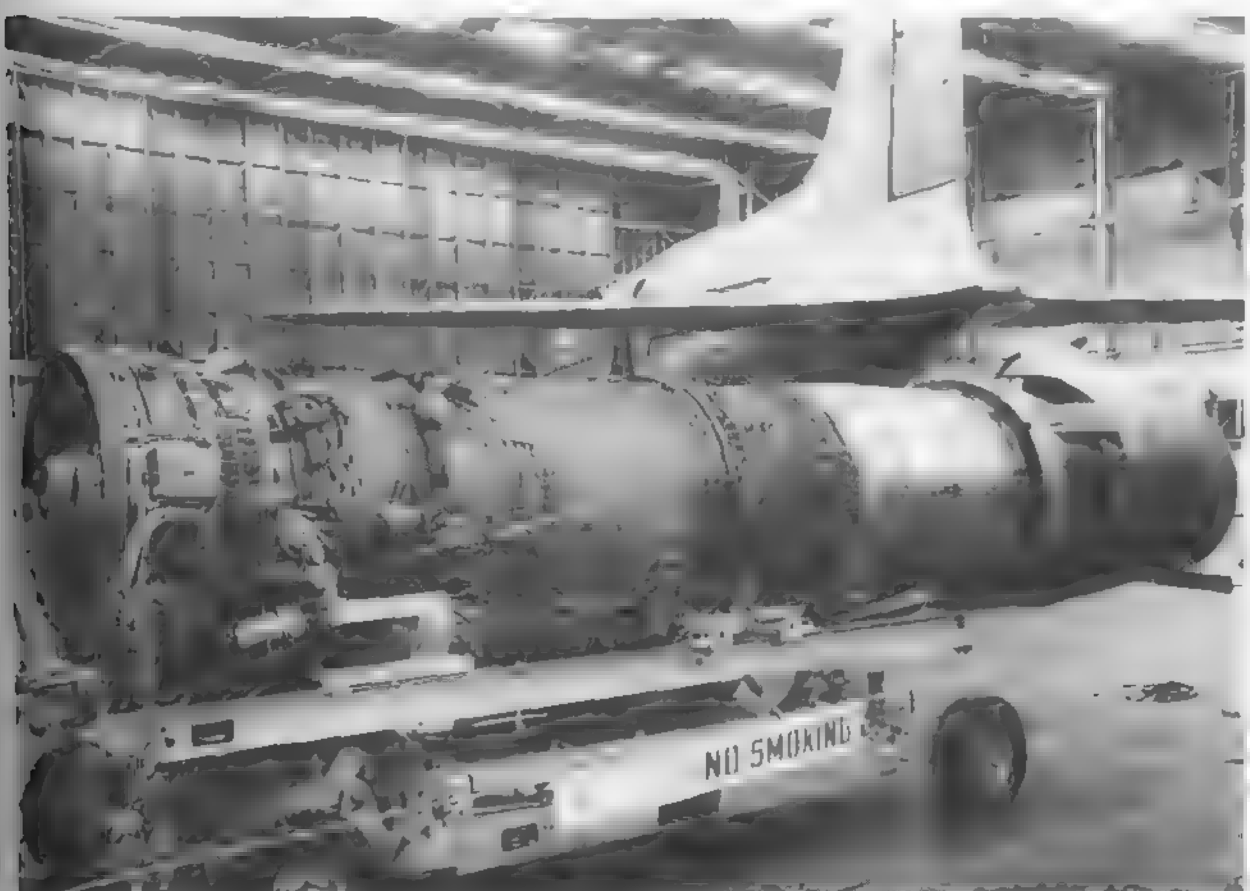
The 340th BG's 4007th Combat Crew Training squadron was the first to receive the FB-111A. The type entered operational service with the 4007th on October 8, 1969.

In March of 1970, the FB-111A SRAM program was initiated in the hope that the type could be SRAM-qualified as rapidly and as effectively as possible. It was of paramount importance to the Air Force that the FB-111A be deployed with the missile on an operational basis as soon as possible. A decision had been made to remove the approximately 80 remaining B-58A Hustler supersonic bombers from the inventory and it was hoped that the new FB-111A could take their place.

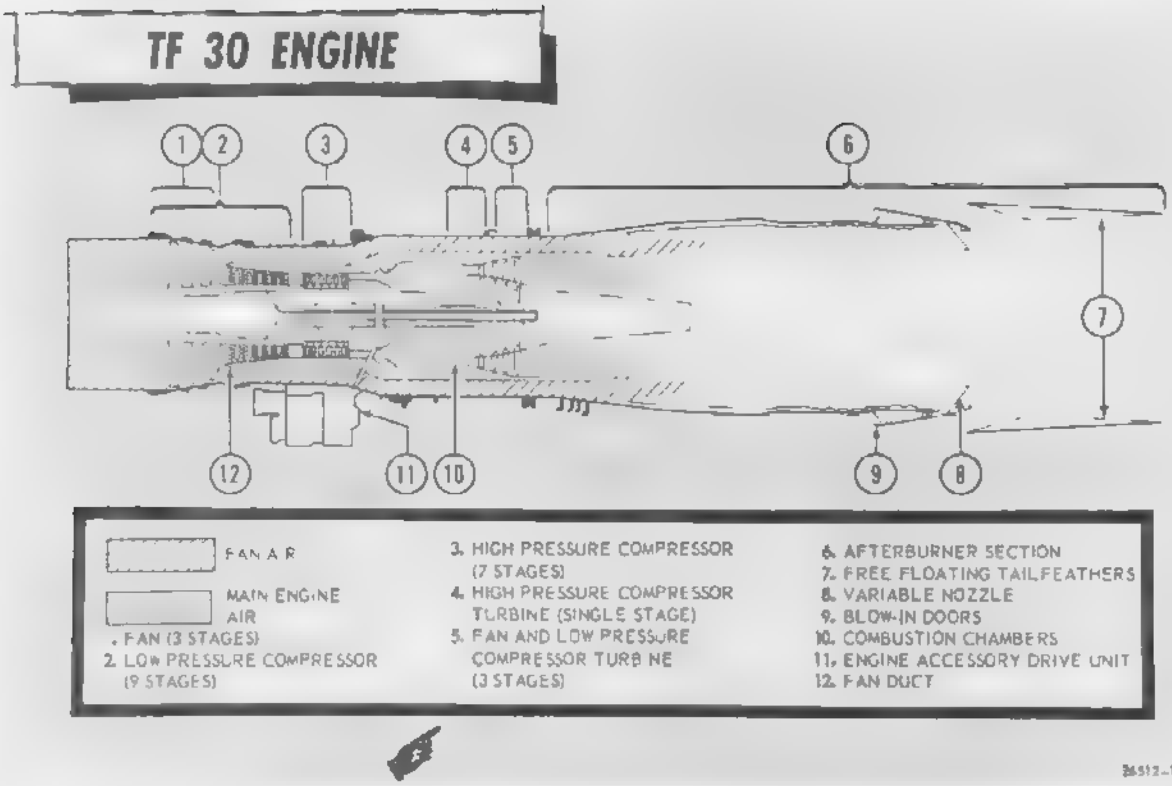
Unfortunately, the early test program did not prove to be overly successful. A number of serious SRAM/FB-111A interface problems were uncovered. During the first year of tests, for instance, there were seven successful launches out of a total of 11 attempted. It was obvious that operational capability was still some time away.

Eventually, efforts to make the FB-111A and the SRAM compatible cost no less than $140 million. Additional flight tests followed the 1970 series and led to a truly effective weapon system. The SRAM/FB-111A combination remains operational with SAC to this very day. On June 30, 1971, the last FB-111A was turned over to the Strategic Air Command.

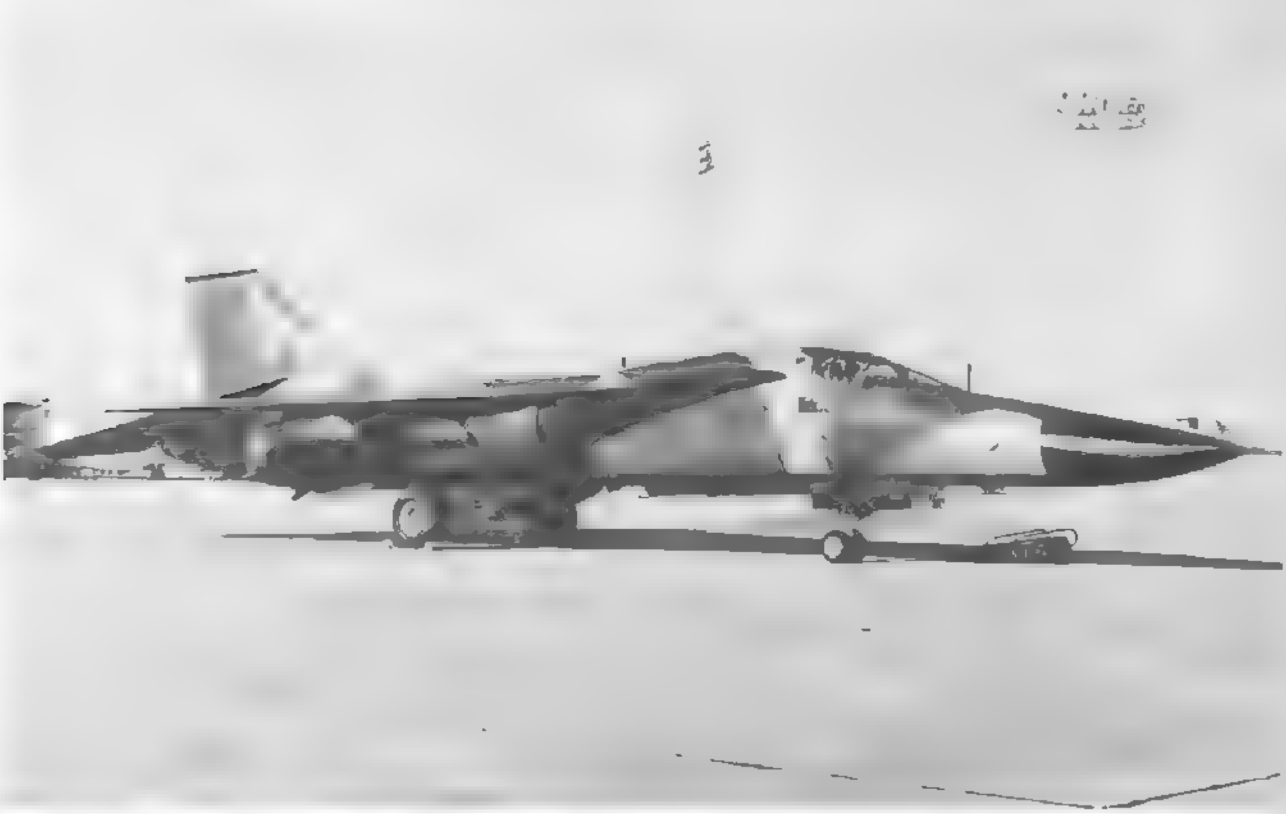
The FB-111A had an estimated per-



The Pratt & Whitney TF30-P-1 engine was used on the prototype airplanes for a short while only. In most cases it was replaced by the slightly improved TF30-P-3. This view shows a P-1 mounted on its carrier following removal from one of the prototype airplanes. The TF30 was the first turbofan engine in the world to be used in a supersonic airframe. General Dynamics photo



This drawing illustrates the major features of the Pratt & Whitney TF30 turbofan engine. General Dynamics photo



The F-111Ds Mk.II avionics system is considered by many to be the most sophisticated in the world. Cannon AFB serves as home field for all F-111Ds in the A.F. inventory. Author's collection.

airplane cost of $9.8 million. This consisted of $4,201,000 for the airframe; $1,735,000 for the engines; $2,550,000 for the avionics; and $1,342,000 for the armament.

In 1972 and 1973, the FB-111A went through an Air Force—sponsored update program. This included the incorporation of an improved ECM system and a number of lesser defense-oriented modifications. The FB-111A serves with the 380th BW (528th BS/529th BS) and the 509th BW (393rd BS/715th BS) and is considered complementary to SAC's more numerous B-52s. FB-111A serial numbers are: 67-159—163; 67-7192—7196; 68-239—292; 69-6503—6514.

F-111K. This was essentially an F-111A variant optimized for use by the Royal Air Force. The British opted for the F-111 following a decision to cancel their outstanding, but expensive, BAC TSR-2. The first—and eventually the only—order for the F-111K amounted to a total of 50 aircraft. This contract was signed in 1966 and cancelled two years later in January 1968.

The F-111K differed from the F-111A in having the bigger and stronger FB-111A—type landing gear and an advanced avionics suit comparable, in some respects, to that of the F-111D. Two of the 50 aircraft ordered were eventually completed. These were turned over the the Air Force for test purposes and redesignated YF-111A following Britain's decision to cancel. The two aircraft were assigned Air Force serial numbers 67-149-150

MAJOR FAILINGS

There have been a number of major problems that have confronted the F-111 throughout its turbulent career. As we will see, not all of them have been solved.

Engine/Inlet Incompatibility. Before it was at least partially resolved, this cost the government and General Dynamics a total of over $100 million. The problem, a compressor stall situation (which is described in detail below), occurred near the outer edges of the F-111's performance envelope. The model most seriously affected was the F-111A, though all F-111s suffered from compressor-stall anomalies at one time or another during their operational lives. Solutions to this problem developed for the F-111A were eventually used in developing partial cures for all other F-111 models.

The compressor-stall phenomenon occurred only at high Mach. At Mach 2 it could be initiated by relatively abrupt high-g maneuvering; at Mach 2.35, it occurred without warning and without provocation—often in level flight.

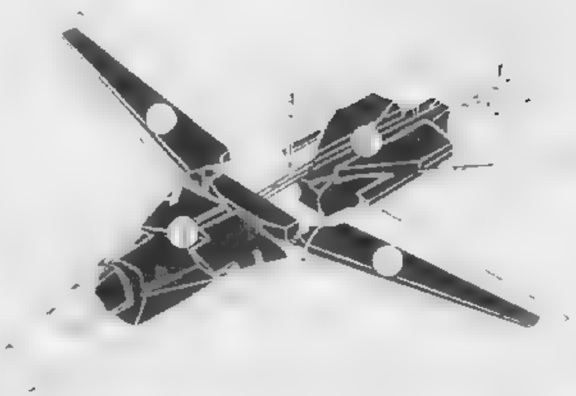
The problem stemmed from the fact that the F-111, as mentioned earlier, was the first production airplane in the world to utilize an afterburning turbofan engine in a supersonic airframe. Until the F-111, experience with turbofans operating at supersonic speeds with afterburners was strictly a wind tunnel exercise.

Though turbofan engines were assumed by the aerospace industry to have somewhat unique intake requirements, the true importance of this was generally overlooked. This oversight proved to be an understandable mistake for General Dynamics, in light of the state of the art; but unfortunately it led to the premature demise of what is today one of the world's most effective combat aircraft.

At high Mach numbers the air entering a jet's intake is moving at an extraordinarily high velocity. From the lip of the intake to the face of the engine's compressor section, many physical changes must take place in order for this air to become compatible and digestible inside the engine. Ideally, the intakes and their associated ducting are straight tubes that serve only to compress the air, slow it to subsonic velocities, and feed it directly to the engine(s). Straight ducting is not always possible, however, and in fact is often a technical impossibility. Landing gear wells, fuel tanks, instrument bays, armament systems and many other odds and ends almost always get in the way. The result is intake ducting that snakes and twists. Such ducting inconsistencies can lead to a number of problems, not the least of which is compressor section stall caused by airflow distortion.

Airflow distortion, simply stated, is where the airflow distribution across the face of the engine compressor section is not uniform. As a result, pressure anomalies develop that lead to excessive airflow across some sections of the compressor section face and virtually no airflow across other sections. This leads to pressure pulses (sometimes heard inside the airplane as a "buzz") which can

Fuel Quantity Data (Typical)

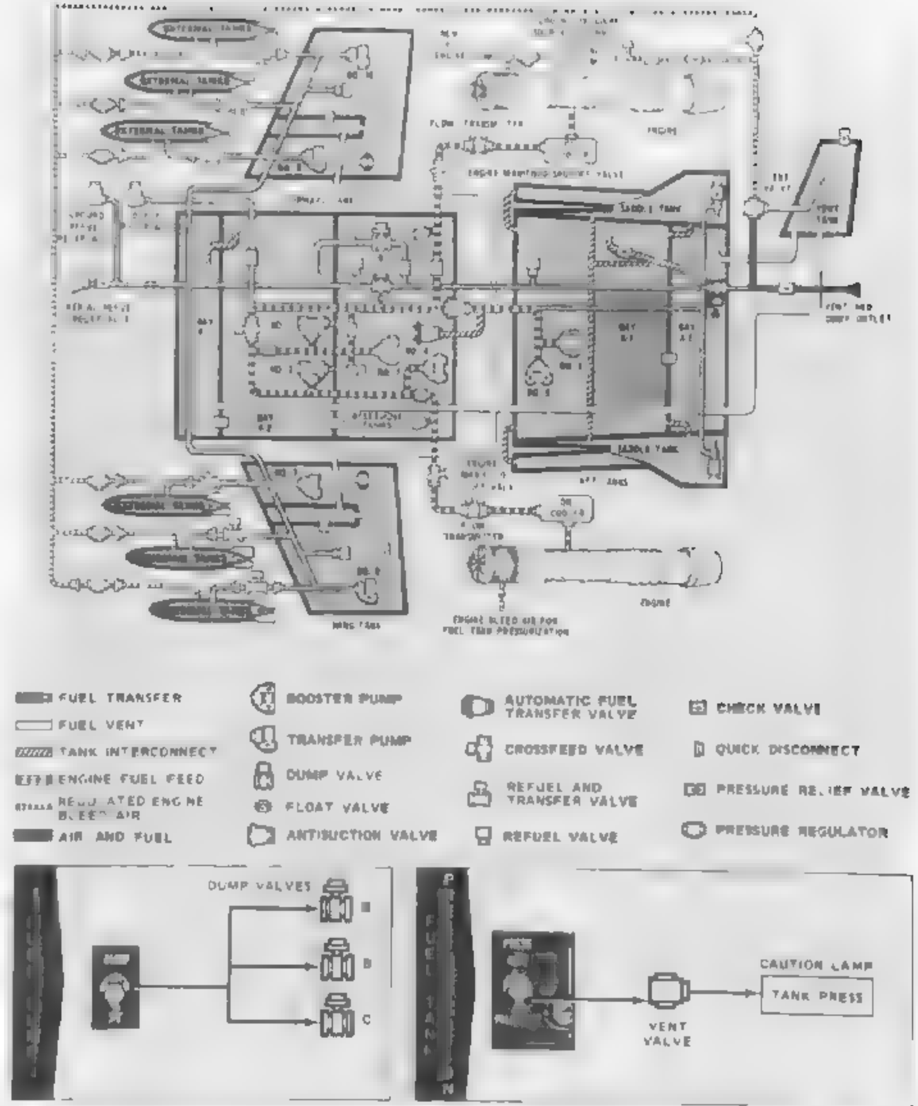


WARNING

THIS CHART SHALL NOT BE USED FOR MISSION PLANNING PURPOSES SINCE ... THE INDIVIDUAL AIRPLANE WEIGHT AND BALANCE ... T.O. 1-1B-40 ... BE USED FOR EXACT FUEL CAPACITY

		U.S. GALLONS AND POUNDS			
		USABLE FUEL		FULLY SERVICED	
		GALLONS	POUNDS	GALLONS	POUNDS
1	LEFT WING INTERNAL TANK	389 2	2 467	390 8	2 477
2	RIGHT WING INTERNAL TANK	389 2	2 467	390 8	2 477
[illegible]	FORWARD FUSELAGE TANK	2 766 6	17 751	2 783 5	17 861
[illegible]	FUEL LINES	28 3	184	53 4	347
4	AFT FUSELAGE TANK	1 426 8	9 287	430 [illegible]	9 30
TOTAL	—	5,002 1	32,156	5 049 4	32,463

Fuel tank layouts of F-111A and F-111B differ somewhat in capacity and arrangement. The F-111A system, for instance, includes a vent tank in the vertical fin. The F-111B had tanks mounted over the engine bays. The F-111A has a total internal useable fuel capacity of 25,542 pounds whereas the F-111B had a useable capacity of 32,156 pounds. General Dynamics photo.



The F-111's fuel system is somewhat more complex than conventional systems due to the large amount of fuel the airplane is required to carry and to the fact that it has fuel tanks inside its variable-sweep wings. Additionally, the variable sweep wings are capable of mounting external tanks. General Dynamics photo

FB-111A was interim bomber development to fill the gap between the Boeing B-52 and its proposed replacement. The latter has yet to be produced and introduced into the operational Air Force inventory and the FB-111A thus remains an important part of the Air Force's strategic bombardment capability. George Cockle photo.

Transient F-111F from Mountain Home AFB, Indiana stops for a breather at Randolph AFB, Texas. Small 2.75" rocket pack is mounted on wing pylon. F-111F is typically used for ground attack duties. Author's collection.

quite literally blow out the combustion process inside the engine. Physical damage to the engine is not uncommon and as a result a relight may be impossible to obtain.

Unfortunately, the F-111 suffered from this intake airflow distortion problem. Straight as its intakes were, they still had a few curves and bends here and there that under certain conditions could lead to poor airflow distribution. At high Mach this problem was particularly critical. At speeds of 1,350 mph or more, the engines were operating at peak performance and all factors governing intake airflow had to be in perfect harmony for compression/combustion functions to be completed according to plan.

The F-111's intakes, though of the unusual quarter-round type and located at the wing-fuselage juncture, were not as unconventional as they appeared to be. In fact, General Dynamics had run thousands of hours of tunnel tests on a wide variety of intake configurations and had concluded that in consideration of the F-111's low-altitude supersonic dash requirement, they were the best over-all design for the job.

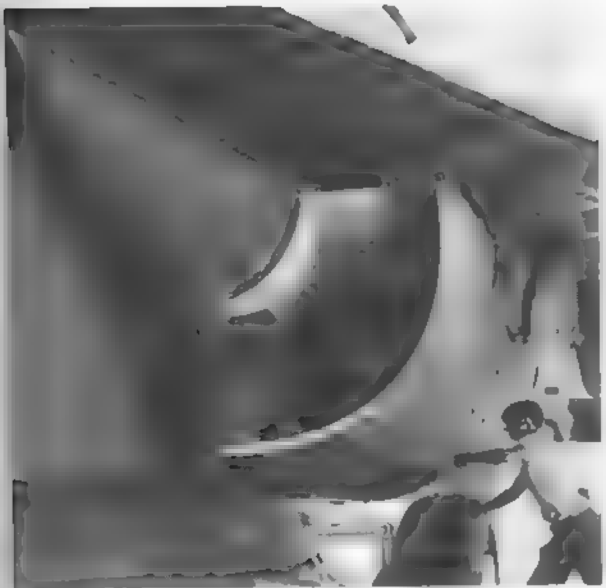
Unfortunately, what held true for low altitudes and moderate Mach numbers did not hold true for high altitudes and high Mach numbers. The reason for this was that at low altitudes high density air formed a different flow pattern around the nose, forward fuselage, and wing juncture of the F-111, thus creating a modestly different flow pattern for the intake. At high altitudes this changed. Due to the significantly thinner air, the flow pattern was different and tended to have a more variable effect on the boundary layer air. Accordingly, some separation of this boundary layer occurred, which in turn affected the air entering the F-111's intakes. The result was distortion, poor flow spread across the face of the turbofan's sensitive compressor, and eventually a choked compressor section.

The cause of the intake problem was soon discovered; but the solution was a long time in coming. Not that a solution was difficult to create; the intake problem could have been cured in a matter of months—if it had been possible to penalize the F-111's performance and still meet contract guarantees. But this was not possible, and the development of a compromise solution proved to be an extremely difficult engineering challenge.

One of the many intake configurations tested during the early days of the F-111's flight test program. Engine compressor stall problems first coming to light on the day of the first flight, would plague the airplane throughout its life. Many intake configurations were studied in the hope that a solution to the problem could be uncovered. General Dynamics photo.

The inlet/engine problem was not totally the fault of General Dynamics. As it turned out, Pratt & Whitney was partly to blame because the TF30 proved to be inordinately susceptible to compressor section stalls. This stall sensitivity was later improved by Pratt & Whitney following a major TF30 redesign effort, but it was never eliminated entirely.

Structural changes brought on by the F-111's compressor stall problems were evinced in an inlet modification program sponsored by both the Air Force and General Dynamics under the code name of Triple Plow. The first of these, known as Triple Plow I, was incorporated into the F-111A design and flight tested on a number of the early RDT&E aircraft. This first modification included an improved splitter plate design



The final solution to the F-111's intake problem was that concocted under the codename of Triple Plow. There were several Triple Plow variants, including Triple Plows I, II, and III. Shown is the Triple Plow installations for an F-111E. Note that, when compared to those of early configurations, the intake spike is much further from the fuselage wall, the splitter plate has been completely removed (though some Triple Plow configurations maintain the splitter plate), and the entire intake has been moved outward from the fuselage a considerable distance. Author's collection.

(curving it outward from the fuselage by four inches), a notched side plate within the intake proper, and a redesigned intake lip (increasing its radius).

The second modification, more radical than the first, was code-named Triple Plow II. This called for a 10 percent increase in the cross-sectional area of the intake, the relocation of the intake almost four inches further out from the fuselage side, and the complete removal of the splitter plate. Due to its complexity, it also demanded a number of major fuselage structural changes, not the least of which was the incorporation of a new intake duct and the redesign of several fuselage frames and skin panels.

Even following the Triple Plow program there was some degradation in airplane performance. This was caused by the slight increase in gross frontal area—which in turn was caused by increasing the size and dimensiona values of the intakes. Most F-111 models fly with serious performance restrictions to this very day.

Wing-Carry-Through-Box. (The variable-geometry wing's version of a wing center section) This was statically fatigue tested in 1968 and discovered to be susceptible to fatigue failure long before its design life was reached. Cracks appeared in a test box at less than 50 percent of F-111 design life. Major redesign of the box proved necessary, and following several additional static test failures it was finally approved for production after surviving a proof loading of several times the minimum requirement.

On December 22, 1969, the Air Force lost its 15th F-111A. The loss was eventually traced to a failure of the forged wing pivot fitting. The Air Force then grounded all F-111s and did not call off the grounding order until July 31, 1970.

In the wake of the December 22nd accident, the Air Force initiated the Recovery program, a $31.2 million test and modification effort that it was hoped would correct all wing structural problems and make the F-111 a flightworthy airplane.

Part of the Recovery program was a series of static ground tests that eventually gave the wing-box an equivalent fail-safe fatigue life of 6,000 hours. As a safeguard, the Air Force ordered North American to develop a titanium box (the General Dynamics box was made of steel). The latter effort, however, did not prove to be a necessary retrofit.

It is interesting to note that the General Dynamics box was a subcontracted article and was built by Selb Manufacturing. During the investigations following the first static failure, it was discovered that Selb had been paying off inspectors for approving unauthorized welds. An FBI investigation followed, which led eventually to litigation that ended in 1973 with a trial jury acquitting General Dynamics of any wrongdoing. Total Recovery program costs eventually amounted to over $100 million.

Empennage Section Drag. This proved to be substantially higher than originally estimated. The F-111 aft-fuselage drag factor was estimated to be some 30 percent of the total drag of the airframe. This was extraordinarily high when compared to the ideal of five percent. The penalty of this high drag was a shortened sea-level supersonic dash range and a substantially degraded ferry range. No solution to this problem was ever developed; and although some improve-

ments in aft fuselage drag characteristics were eventually incorporated in production airplanes, they were not enough to make any significant difference in performance.

Excessive Weight. Weight was to be a problem that plagued the F-111 throughout its life. As mentioned earlier, the groundwork was laid for the weight problem when the Air Force demanded, over the Navy's strong objections, that the F-111 be capable of at least Mach 1.2 "on the deck." This performance requirement needed a particularly strong airframe, which in turn called for increased structural weight. Increased weight led to bigger engines. Bigger engines meant more fuel. More fuel meant more weight. It was an endless circle.

The F-111 became an extraordinarily dense airplane by the time the first machine rolled from General Dynamics' plant doors. The weight problem had become serious during the early months of the program when it was discovered that structural requirements were tougher to meet than originally estimated. By the airplane's first flight gross weight for a conventional mission was expected to be an unbelievable 92,000 pounds—30,000 pounds more than the original September 1961 specification!

Although the weight increases for the Air Force airplane were critical, they were not nearly as important as the increases being suffered by the Navy's weight-sensitive F-111B. This airplane, with its advanced Hughes AWG-9 Phoenix air-to-air missile system, had been scheduled for an all-up gross of 55,000 pounds—the maximum fighter weight permissible aboard the biggest U.S. aircraft carriers. By the time of the prototype F-111B's first flight, this figure had increased to an absolutely unpalatable 75,000 pounds—a figure, as we shall see, that spelled almost certain program termination.

Minor Problems. Many small problems were suffered by the F-111 during its first few years of operation. These included landing gear malfunctions; terrain-following radar malfunctions; inadequate electronic countermeasures capability (the deficiencies of which were discovered somewhat disastrously during operational service in Vietnam); navigation systems malfunctions; weapons release system malfunctions; tail servo actuator malfunctions; and at least one malfunction caused by poor mounting of the airplane's onboard General Electric M-61A-1 multi-barrel cannon.

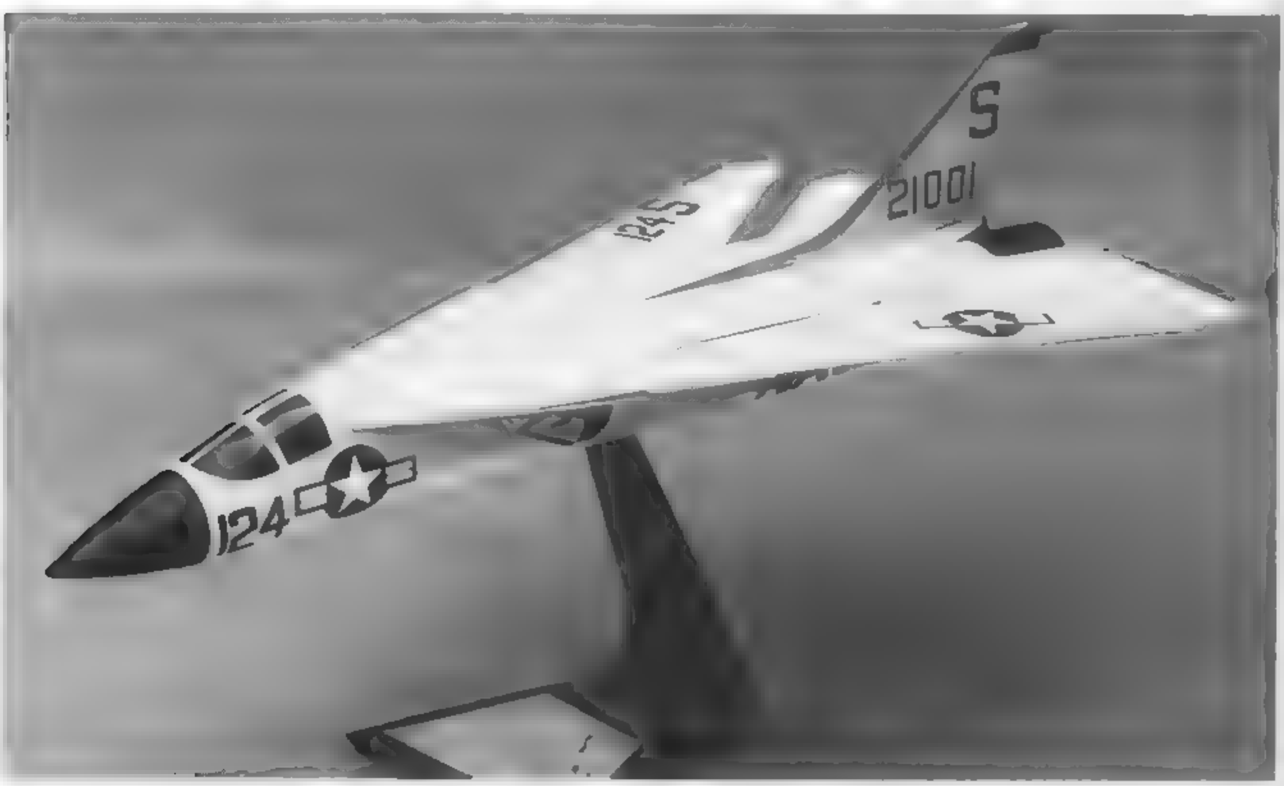


Photo depicts a model of the Navy's F-111B airplane in its near-final form. Vertical fin and intake splitter plate would eventually be redesigned, however. General Dynamics photo.

Final F-111B full-scale mock-up, built at General Dynamics plant, was quite similar to the airplane as actually constructed. Vertical fin would later be shortened and broadened in order to meet changes in Navy requirements. General Dynamics photo.

THE NAVY STORY

Coerced into building a multi-service fighter-bomber under the original TFX doctrine, several of the companies involved in the preliminary TFX bid period began groping around for technical assistance in the form of a partnership to fulfill the dual requirements outlined in the original technical specification.

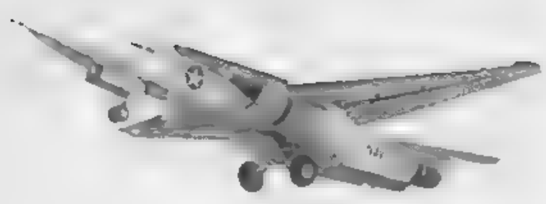
Air Force and Navy airplanes are built to a number of significantly different physical requirements. The former, for instance, operate almost exclusively from land bases with long, permanent runways; while the latter operate almost exclusively from short, never-in-the-same-spot aircraft carrier decks. Land bases have few physical restrictions; aircraft carriers have many. Weight and size, for instance, mean little to a facility with a 15,000-foot concrete runway and a half-million acres—but they mean one hell of a lot to a floating postage stamp with a 900-foot flat steel deck and only a few hundred thousand square feet of surface area.

Each of these differences makes for a big structural difference in the design of the airplane's airframe. Navy aircraft require substantially beefier structures than their Air Force counterparts because carrier landings and takeoffs are extraordinarily demanding of airframe and systems. Extra beef means extra weight and extra weight means more powerful engines—as General Dynamics, Grumman, and McNamara eventually found out, never the twain services' requirements shall meet.

Like other companies involved in the early TFX bidding, General Dynamics was weak in a number of Navy-related areas. One, it had been many years since General Dynamics (or any of its several predecessor companies) had built a Navy airplane, and two, its political connections with influential Navy higher-ups were thin at best.

It was only natural then that General Dynamics should give serious consideration to a partnership—preferably with a company that could cover both of General Dynamics' important Navy-related gaps. General Dynamics, like its fellow bidders, was well

Roll-out of prototype F-111B took place at Grumman's Calverton, Long Island, New York plant. Readily apparent were the many external differences between it and its Air Force stablemate. Shorter, stubbier nose was quite distinctive. Grumman photo via Jim Stevenson



First flight of prototype F-111B took place from Calverton plant on May 18, 1965. Grumman photo via Jim Stevenson

aware of the great potential implied by the impending program. Billions of dollars in gross sales were at stake. It was no wonder that a number of companies, including General Dynamics, were open to the idea of a production program partnership.

Due to its Grapevine, Texas proximity some thirty miles to the east of General Dynamics' Fort Worth Division plant (where the TFX proposal was being developed), Vought Corporation was a natural team mate choice. Vought not only had many years of Navy airplane manufacturing experience, it also had the political ties. Unfortunately for General Dynamics, Vought also had ideas of its own. With its experience and contacts, Vought felt that it had a good chance to snare the entire TFX program contract intact, without any outside help. So much for that partner.

Though not as conveniently located as Vought, Grumman Corporation of Bethpage, Long Island, New York, was perhaps the premier builder of Navy aircraft in the world. Grumman's relationship with the Navy was well-nigh legendary. Thousands of Grumman-built Navy fighters and fighter-bombers had rolled off the Bethpage and Calverton production lines, and the vast majority had been built hand in hand with the Navy's ultimate blessing.

Conveniently, Grumman too had been an early contender in the TFX competition, but unlike Vought was very much open to the idea of joining forces with another team. Grumman's philosophy was simple: it had been building Navy airplanes for years—it was not interested in building Air Force airplanes—and if it could find a company interested in building the Air Force half of a bi-service product, it would be happy to handle the Navy portion.

By late 1962, Grumman and General Dynamics had completed negotiations by which the two would join forces and make a joint bid for the TFX contract. Meanwhile Grumman, in light of the substantially different air-intercept requirements of its TFX version, also joined forces with Hughes Aircraft and proceeded to develop the air-to-air missile system that would become the very heart and soul of the new Navy airplane.

The Hughes/Grumman relationship was not technically a new one. As relates to this program, it had actually started in late 1958 when the Navy had awarded the Douglas Aircraft Company a contract to develop a long-range stand-off missile carrier known as the F6D *Missileer*. A subsonic, straight-wing twin-turbofan design with a duration approaching half a day, the F6D was to have been designed by Douglas and produced by Grumman.

Perhaps the most important aspect of the entire F6D program, including the airframe, was its impressive weapon system. The Navy had decided early-on to take a new approach to air interception with the new *Missileer* and, accordingly, had requested proposals from the aerospace industry for a stand-off air-to-air missile capable of intercepting an aircraft at extreme ranges and altitudes. Missile design parameters included a maximum range of 100 miles, a maximum altitude of over 100,000 feet, and a maximum speed of over 2,500 mph.

With a sophisticated search and track radar, it was proposed that the F6D find its target, determine its location and course, and destroy it with one of the new missiles. In effect, the missile would be doing all the work—the *Missileer* would serve only as an airborne launching pad.

Eventually, the Bendix Corporation won the contract for the new AAM-N-10 *Eagle* missile and its associated electronic systems. Douglas and Grumman pursued the various airframe problems, and Pratt & Whitney wound up with the engine contract. (The F6D was to be powered by two Pratt & Whitney TF30s rated at 16,500 pounds thrust each—without afterburner.)

The F6D program was moving ahead at a rapid pace when suddenly, almost without warning, it was cancelled. By this time—it

was April 1961—a lot of funding had been pumped into the program, particularly into the missile system electronics. A number of folks were upset. The reasons for the cancellation were never made particularly clear, but it was assumed that Navy commanders had never fully approved of the airplane's basic premise. Their idea of an interceptor was not a subsonic stand-off launching platform.

Though most of the program's funding was immediately withdrawn, enough remained for Grumman and Bendix to continue the development of the basic Eagle system. Bendix eventually bowed out of the program, though not before leaving Grumman with most of what it had learned and developed.

When Hughes and Grumman joined forces shortly afterwards, this same technology base was transferred to the former and utilized as a guideline for developing the air-to-air weapon system that was eventually to serve as the fighting might behind the upcoming TFX.

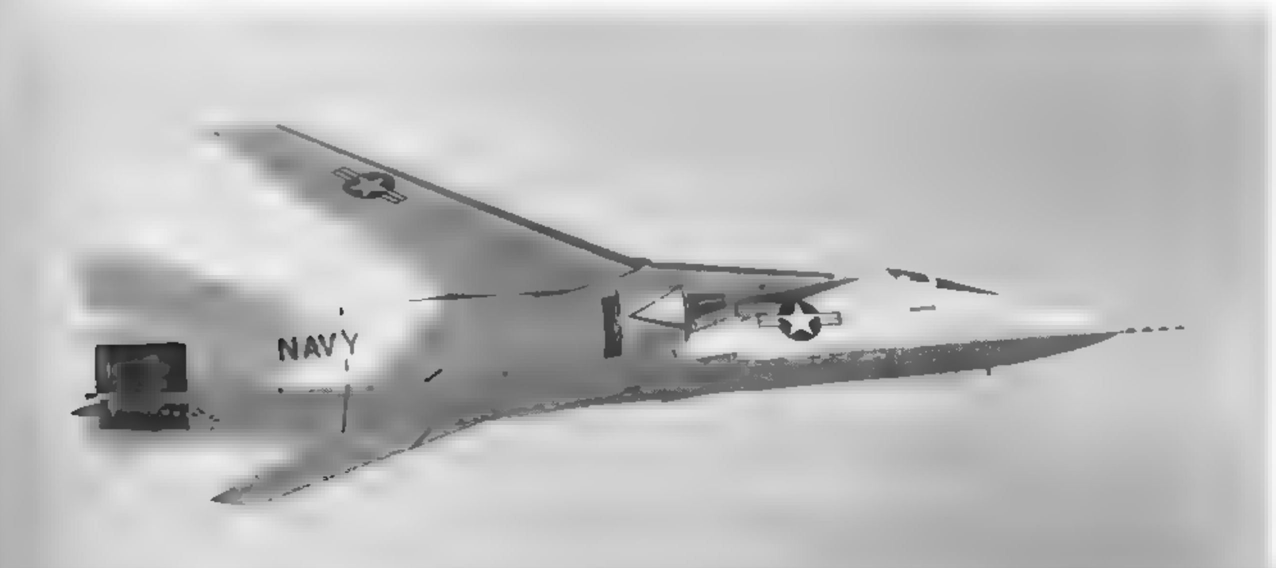
By the time of the TFX program's birth, Grumman and Hughes were well along on the development of the new air-to-air missile. In fact, it had already progressed to where the Navy felt justified in awarding Hughes a contract. This funding was for what was to become known as the AWG-9 radar system and a greatly improved Bendix Eagle called the (AAM-N-11) AIM-54 Phoenix.

As a point of interest, it should also be mentioned that a significant portion of the technology that went into developing the AWG-9 and AIM-54 came from another significant Hughes program. This was the awesome multi-Mach—capability AIM-47 which had been developed for the Lockheed YF-12A long range interceptor. In fact, AIM-47 aerodynamics were quite similar to those of the AIM-54 and much of the latter's electronics was an exact duplicate of that of the former.

As mentioned earlier, the Navy reached an agreement with the Air Force in which the Navy's financial obligation to the TFX program would not come into play until the advent of the first production aircraft. Until that time, all funding would come out of Air Force accounts. However, the Navy would fund the missile system development outright and would also watch over its integration into the new airplane.

When General Dynamics and Grumman were chosen as the winning team in December of 1964, Grumman immediately commenced work on what was to become known as the F-111B. This was the model specifically designed to the general Navy TFX requirement and as such was the airplane designed to carry the new AIM-54A/AWG-9.

The development of the F-111B, it was assumed, would take somewhat longer than that of the Air Force F-111A due to the demands of the more advanced missile system on the F-111B and its associated airframe/system integration problems. Most



Beautiful inflight photo of F-111B flying off Long Island. Wings are at intermediate sweep position for long-range, high-speed cruise. Additional wing area and improved aspect ratio of F-111B (created by increase in span) improved its ability to loiter. Grumman photo via Jim Stevenson.

unfortunately, this prediction proved to be unerringly accurate.

Unquestionably, the biggest problem facing Grumman and General Dynamics engineers was total aircraft weight. As mentioned earlier, from the beginning all parties involved knew they had a tiger by the tail. Hoping that solutions to the weight problem would develop of their own accord, a decision was made to complete the first three prototype F-111Bs (Bu.Nos. 151970, 151971, and 151972) without worrying about their weight and then tackle the weight problem starting with prototype number four. This would allow the preliminary flight test program to get underway at the earliest possible date and thus clear the airplane for more advanced programs as the schedules allowed.

Upon winning the TFX contract, Grumman and General Dynamics had promised the Navy an empty weight of no more than 39,000 pounds. Sadly, the demands placed upon the structure by various performance and system requirements eventually led to a figure that was almost *five tons* over this! The F-111B, to put it politely, was in very serious trouble!

With the roll-out of the number four airplane Grumman initiated a program under the acronym of SWIP (Super Weight Improvement Program). The objective was to strip the airplane of every possible ounce of extra weight and get the empty weight figure down to a more readily digestible number.

SWIP, as it turned out, did little good. The Navy now stepped in and began fighting with the Pentagon over whether or not it was feasible to go ahead with the program. The Pentagon, possibly influenced by the program's importance to the entire U.S. military posture, argued that it was, and that the Navy could go straight to hell!

The Navy countered with similar sentiments, but also asked that they at least be given a chance to completely review the program and make recommendations that might solve a few of the new airplane's many problems.

The F-111B, following the first flight of the prototype airplane (Bu. No. 151970) from Grumman's Calverton, Long Island, New York plant on May 18, 1965, had been slapped in the face, as it were, with the same compressor-stall problem that had put the damper on the Air Force's floundering F-111A. Additionally, the F-111B, due to its weight and other failings, also suffered from a problem unique to carrier-borne aircraft—it had poor wind-over-deck characteristics

"Wind-over-deck" is the phrase used to describe the wind speed across the deck of an aircraft carrier that is necessary for an airplane to safely takeoff and land. The F-111B actually had *better* wind-over-deck performance than any other Navy jet. Unfortunately, the TFX requirements were substantially different from those of its predecessors and it was in meeting these that the F-111B failed.

But, what the Navy was really concerned about was the F-111B's weight/speed combination. There was a legitimate concern that

The F-111A and F-111B were rarely photographed together. Here, during stopover in Fort Worth, Texas, the two models sit side by side at General Dynamics plant. Note differences in nose radomes and F-111B's shorter vertical fin and rudder. General Dynamics photo.

standard carrier arresting gear would be operating at or near maximum capacity with the F-111B. In truth, this fear was unfounded as it was well known that a number of operational Navy aircraft with higher landing speeds and similar gross weights had been operating from carriers for years with no adverse effects. (The most noteworthy aircraft among these were the Douglas A-3 and the North American/Rockwell A-5.)

In order to placate Navy brass, General Dynamics and Grumman embarked on a mod program that would permit the F-111B to land at what the Navy considered to be a reasonable speed. These mods included increases in flap deployment angle and the addition of an extra section of leading edge flap on each wing. Eventually the landing speed dropped to the 115 knots requested by the Navy, but not without severely penalizing the airplane's directional stability.

SWIP was eventually followed by another weight improvement program under the acronym of CWIP (Colossal Weight Improvement Program). CWIP, too, went through a number of perturbations, and though effective to the tune of a ton was actually an act of futility. Not only was the weight pared relatively insignificant, it was barely in keeping with planned weight growth!

SWIP and CWIP eventually trimmed a total of 2,373 pounds from the empty F-111B, which, as one observer later put it, was "like peeing into the Pacific and trying to raise the tide." Gross weight, in the meantime, crept upward from the original guarantee of 62,788 pounds to an almost unbelieveable 79,212 pounds—no less than *eight tons* more than what the Navy thought it could live with!

Throughout these immense increases in weight, Grumman, General Dynamics, the Navy, and the Secretary of Defense all sat around pulling their hair. Detailed accounts of the weight increases were tabulated almost daily and examined with a fine tooth comb.

The following list of weight increases, documented about two-thirds of the way through the F-111B program, gives some idea as to the immensity of the problem:

Omissions from estimates in early proposals	1,019
Tighter specifications following Navy review	684
Changes in load and stiffness requirements	772
Alterations in basic configuration	1,862
Engines, avionics, and other government-furnished equipment	351
Miscellaneous government-required changes	385
Miscellaneous general changes	4,608
Total	9,681

In late 1968, the F-111B was tested aboard the U.S.S. Coral Sea. Though, by this time, the Navy's participation in the TFX program was virtually a dead issue, a decision by the DoD led to consumation of the tests for research purposes. Surprisingly, the F-111B proved to be quite carrier suitable. Few problems were found with deck stowage and general shipboard performance. General Dynamics photo

In truth, the real trouble behind the F-111B's weight problem was the Navy. In short, the Navy simply did not want the F-111B. By insuring that it would never overcome its overweight status, it quietly sealed the airplane's ultimate fate.

The Navy was opposed to the F-111B for two very basic reasons: 1) the F-111B was not specifically designed to the Navy's own requirements, and 2) the Navy's requirements, by edict of the Secretary of Defense, had to be subordinated to those of the Air Force.

To weasel out of the program, the Navy surreptitiously decided to take a complex course of action that would accomplish either one of two things: 1) it would force General Dynamics and Grumman to build an airplane exactly to Navy specifications (which would in turn lead to a virtually new airframe with almost no Air Force commonality), or 2) it would lead to total program cancellation and the birth of a totally new replacement project.

The Navy implemented their (consciously or not) somewhat devious anti-TFX plan by absolutely insisting on four difficult requirements: 1) the airplane must have an encapsulated ejection system, 2) the airplane must be able to carry at least part of its missile armament internally, 3) the airplane must offer great internal volume for the Phoenix missile system avionics, and 4) the airplane must have a minimum loiter time of 3.5 hours at a range of 150 miles from its parent carrier.

Any one of these four requirements could have dealt the program a lethal blow. Together, their added weight spelled certain disaster.

During the course of discussions with General Dynamics and Grumman, the Navy was given the chance on a number of occasions to rescind any one or all of the above demands. On each and every occasion they refused.

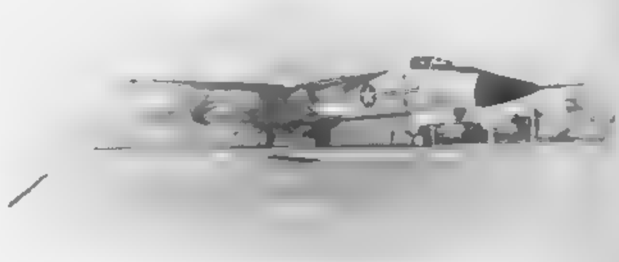
It is interesting to note that neither before nor after the F-111 has the Navy been so adamant about the inclusion of even one of the aforementioned requirements. A startling example can be found in the F-111B's immediate successor, the Grumman F-14A. This airplane was not required to incorporate *any* of the four. It had no encapsulated ejection system. It carried all of its armament externally, with the exception of its rotary cannon. It offered little if any growth space for the Phoenix missile system avionics (which are, in today's version of the Phoenix, roughly half the size of the mid-1960s version). And it did not have two-thirds the loiter time demanded of the F-111B—no matter what the distance from the parent carrier!

Though as many as 705 F-111Bs were on order at one time in 1964, by 1966 this figure had dropped to 50 aircraft. Solutions to the airplane's weight problems were being developed frantically by the two contractors (and being countered just as frantically by new Navy requirements and changes). Unfortunately, by mid-1967 the writing was on the wall. A last-ditch effort to overcome the weight increases through pure power, via the incorporation of the improved and uprated TF30-P-12, eventually died on the vine. To complete the coup de grace, unit costs skyrocketed from an original estimate of $3 million to a final estimate of over $8 million.

The Navy finally achieved its objective when, in light of the myriad problems facing the airplane, the Senate Armed Services Committee voted on March 28, 1968, to cancel the F-111B contract. This had been preceded by an unprecedented act by Grumman. During the preceding October it had responded to a request from the Defense Department with information pertaining to how the F-111B compared with contemporary and future Soviet military aircraft—as well as a proposal for a totally new "lightweight" fighter to replace the F-111B!

The committee's decision to cancel the F-111B tactfully avoided cancellation of the Hughes AWG-9/AIM-54 Phoenix system, obviously because of its adaptability to future programs.

Once the verdict had been turned in by the committee, the judge's final sentence was



February, 1968 PAX River tests of the F-111B proved that the airplane was fully capable of operating from the deck of an aircraft carrier. 151974, used for many of the carrier-related trials, is shown in photo. U.S. Navy photo via Jim Wogstad.

only a matter of time. It came, quite expectedly, on July 10, 1968. The F-111B program was officially terminated by the U.S. government.

The Navy and Grumman were overjoyed. Now they could proceed with a program of their own choosing. Quietly and efficiently they did just that. A development effort that had been on the back burner for a number of years, soon to be called the VFX (Navy Fighter Experimental), was suddenly moved into a front row seat. The result, Grumman's ultimate fighter, would take to the air less than three years later. It would be designated F-14 *Tomcat*.

The Navy and Grumman surreptitiously (very little news of the event was ever leaked to the press) elected to go ahead with F-111B carrier trials even though the program had been officially terminated. These trials, aboard the U.S.S. *Coral Sea*, took place in late 1968. Surprisingly, the results were quite impressive. Navy pilots and deck crews admitted later that the airplane was quite compatible with general carrier operating procedures. No difficulties were found with takeoff, landing, arrestment, or on-deck stowage.

A grand total of seven F-111Bs were completed by Grumman before the program officially and mercifully ended. Airplanes four, five, six, and seven (Bu. Nos. 151973, 151974, 152714, and 152715 respectively) were the only ones to benefit from the various SWIP and CWIP exercises, and the performance improvements over the three earlier prototypes were substantial. Airplanes six and seven, which incorporated the TF30-P-12 engines, were considered production standard. The seven aircraft together logged a total of 1,748 hours during the course of 1,173 flights. Three F-111Bs were damaged beyond repair before the flight test program ended.

The cancellation of the F-111B had a devastating effect on the overall F-111 program. The Air Force versions were still suffering from compressor stall problems (along with a host of others as outlined earlier), and in general things were not going well.

General Dynamics had been fighting an uphill battle from the very start. Neither of the two major services had really ever wanted the airplane, and when the Secretary of Defense elected to ram it down their throats the result was complete antipathy.

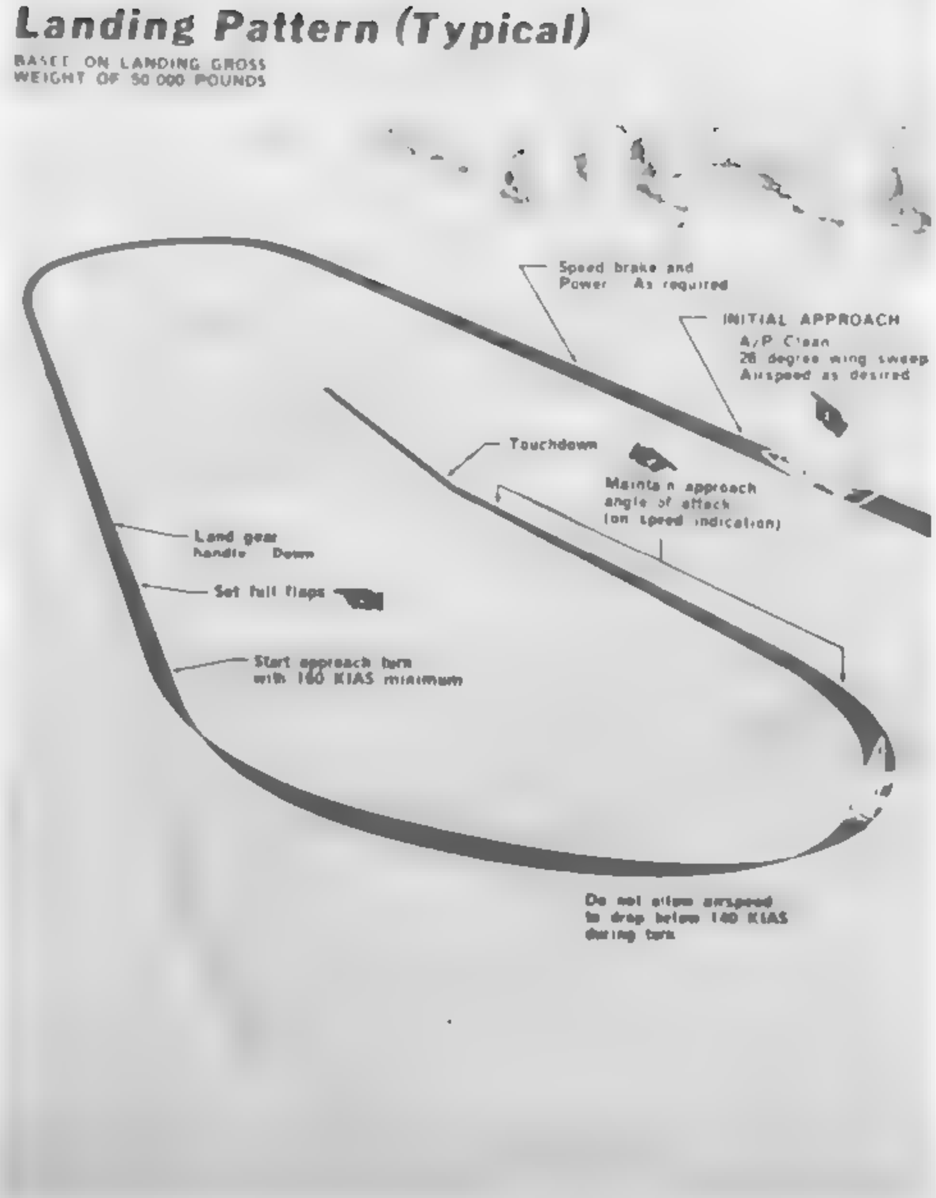
As the first of the Air Force F-111As began to enter operational service, the general feeling toward the airplane was definitely negative. Flight crews were leery of it, ground crews lacked experience with it, and manufacturer's support was lacking. Spares and technical assistance were particularly difficult to come by. And production, maintenance, and operating costs were overwhelming; from an original contract guarantee of approximately $3 million per airplane, the unit figure was now bouncing around the $8-10 million mark.

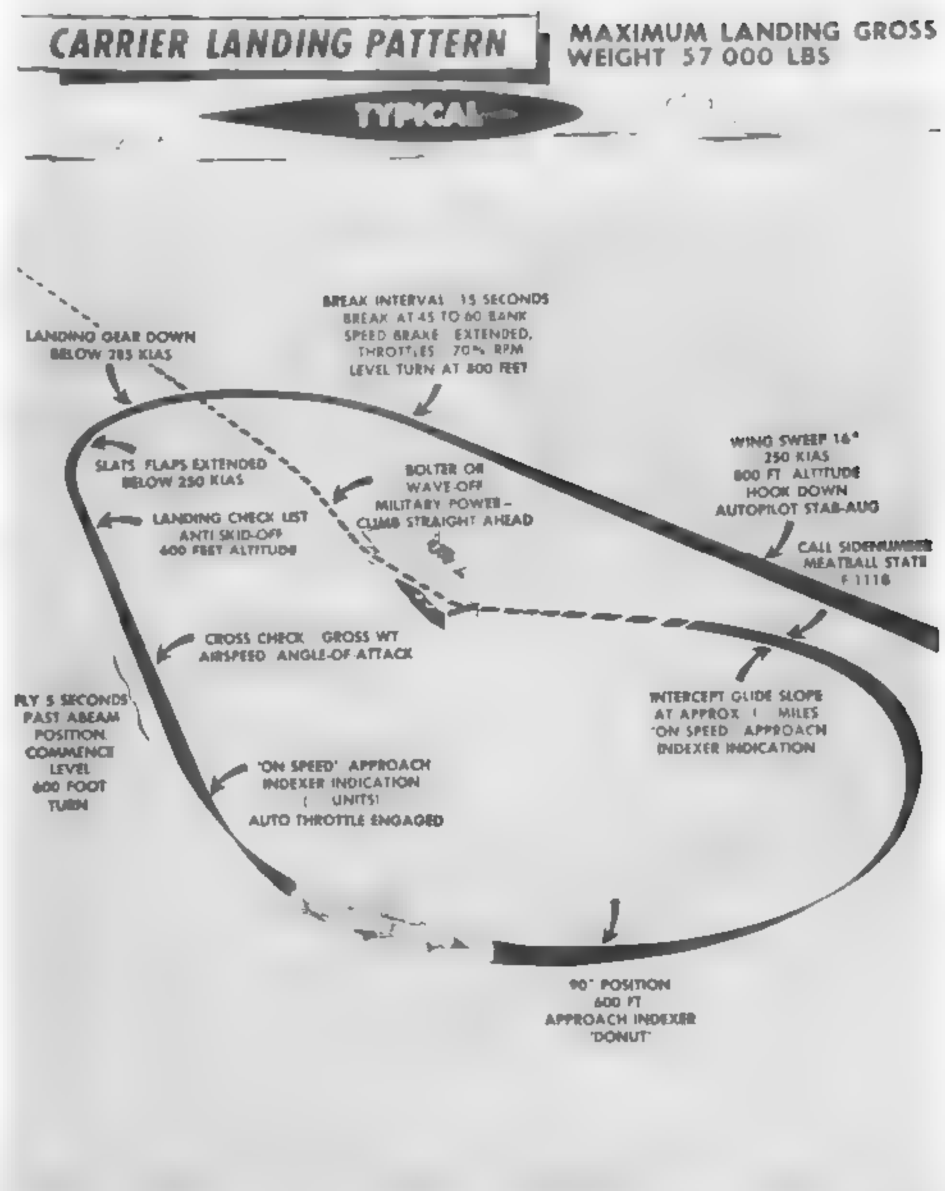
THE AARDVARK GOES TO WAR

In the spring of 1967, a small number of preproduction F-111As participated in a series of weapons delivery tests near Nellis Air Force Base, Nevada under a project codenamed Combat Bullseye I. These tests were quick to verify the superior weapons delivery capabilities of the new variable-sweep-wing fighter-bomber. In fact, the results were so good that a decision was made by Air Force commanders to deploy the airplane to Southeast Asia as soon as possible. They hoped that combat experience would prove the F-111's capabilities once and for all.

The Air Force also hoped that such a deployment, with favorable results, would give the new airplane a new lease on life. Moreover, it was assumed that actual combat experience with the plane would improve pilot and ground crew confidence, both of which were quite low at that time. So under Combat Lancer, a small detachment of six F-111s from the 474th Tactical Fighter Wing (Nellis Air Force Base) was shipped off to Southeast Asia on March 15, 1968. Two days later, on the 17th, they arrived at Tahkli Royal Thai Air Base.

It should be noted that before their deployment to Southeast Asia all F-111As had gone through an update program codenamed Harvest Reaper. Initiated in June 1967, this program was designed to cure many of the F-111's known shortcomings. Modifications included the addition of more avionics and the modification and overall





Landing patterns for F-111B and F-111A, respectively. General Dynamics photos

TACT (Transonic Aircraft Technology) testbed F-111 was early test F-111A modified to incorporate Whitcomb-developed supercritical airfoil section wing. Airplane is shown in these photos prior to its first flight at Edwards AFB. Author's collection.

improvement of existing electronic counter measures equipment.

Combat Lancer, unfortunately, was not a success. During four weeks of activity and 55 missions of questionable effectiveness, two of the six F-111As were lost. Two replacement aircraft left Nellis shortly afterward.

On April 22 a third airplane disappeared. This led to Combat Lancer's immediate termination, although the remaining five aircraft stayed on in a semi-operational state until mid-November, when they returned to the U.S.

Eventually, investigative teams concluded—and rightly so—that the F-111's combat baptism had been a bit premature. The three accidents were thought to have been caused by equipment failures and/or pilot error, rather than enemy action. Most of the missions had been flown at low altitude, at night, and often in adverse weather conditions. It was assumed that relatively minor mistakes had caused the losses. In fact, malfunctions were known to have occurred in the F-111's terrain following radar system and, coupled with a horizontal stabilator actuator anomaly, were almost certainly the causes of two of the three accidents in Southeast Asia.

It was to be almost four years before the F-111 returned to Vietnam. Finally, two squadrons, the 429th and the 430th, both based at Nellis, were sent over. They were in combat no less than 33 hours after leaving their home base in Nevada on September 27, 1972.

It was during this second Vietnam deployment that the F-111 finally came of age. Flying out of Tahkli, the aircraft proved itself once and for all. In the midst of the extraordinarily rainy monsoon season it unerringly hit targets in all parts of Southeast Asia and Laos. Amazingly, it fought without the assistance of *Iron Hand,* the electronic countermeasures escort aircraft normally required during missions of this type. The F-111 also flew without the assistance of vectoring EC-121s or the inflight refueling assistance of KC-135s.

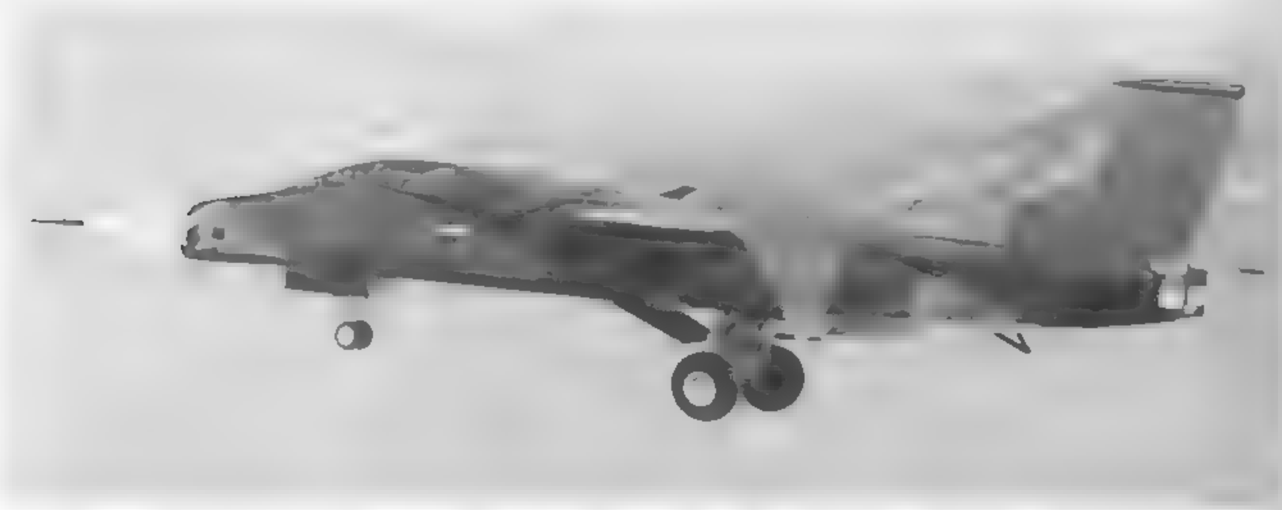
Vietnam F-111 operations were not without their problems. Seven additional aircraft were eventually lost. However, a total of more than 4,000 F-111 missions had been flown—a remarkably good survival record.

Several of the losses were later attributed to miscellaneous technical problems. A number, however, were from enemy action—somewhat of a surprise in light of the F-111's sophisticated electronic countermeasures capability and its various penetration aids.

Though Vietnam proved a tough testing ground for the F-111, it emerged at the other end as an airplane much admired by its crews. Pilots found it quite capable of living up to its stated capabilities, and in fact under certain conditions it proved to be more capable than what they bargained for.

For instance, as part of its mission capability the F-111 has a selectable ride mode when flying in low-altitude terrain-following radar conditions. There are three ride options: soft, medium, and hard. At fifty

Air-to-air photo of TACT F-111A shows underside of supercritical wing. Note exaggerated camber which is discernible at the root section. This was the first variable-sweep-wing airplane in the world to fly with a supercritical wing. NASA photo.



The second F-111E off the General Dynamics production line was bailed to NASA by the Air Force Airplane was used to develop a baseline for super critical wing TACT F-111 and was also used for intake development work NASA photo.

NASA has used a number of F-111As for various exploratory flight test programs. Included among these was 63-9771, shown. The F-111A's variable sweep wing offers unique testing possibilities as few other operational airplanes in the world have this feature.

feet and 450 knots. If there are hills and mountains around, it is wisest to pick the soft ride! The continuous pounding and bumping in the hard ride mode is apparently something that cannot be withstood by crews for more than short periods of time. Pilots claim that under extreme conditions the airplane can cycle through plus and minus four g's at the drop of a hat—and that it can do it for hours on end.

Today, nearly fifteen years after the F-111's first full service introduction, it has quietly and very successfully integrated itself into the USAF mission. It is well liked by its flight crews, fully understood and appreciated by its ground crews, and today is an important part of this country's defensive and offensive capability. Most of its bugs finally have been eliminated, and the mean time between failures of most of the major components is high. Interestingly enough, this is true even of the gremlin-plagued F-111D—assuming enough spare parts are available.

OTHER DEVELOPMENTS

Because of the F-111's innate versatility, there have been a number of attempts to utilize the basic airframe in tactical and strategic areas not directly related to its present fighter-bomber mission. Among these have been photoreconnaissance, strategic bombing, and electronic countermeasures.

The photoreconnaissance efforts, with the exception of a recent Royal Australian Air Force program involving four F-111Cs, have for the most part met with failure. Unfortunately, the Air Force's RF-111A, which is the best known example, was cancelled. This was not because of an inability to perform, but because of an extraordinarily high price tag. In the end only one prototype flew, and it was later reconfigured to normal F-111A standards.

The F-111 bomber came about when it was decided that an interim airplane was needed to fill strategic bomber requirements while the new Advanced Manned Strategic Aircraft (AMSA) was under development. Seventy-six FB-111As were eventually built and deployed. The majority of these are still in SAC service.

More advanced bomber F-111s have surfaced sporadically over the years as in-house programs at General Dynamics. The concept of using the basic F-111 airframe as a bomber has in fact been maintained as a strong possibility from the program's very beginning. Beyond the eventually ordered and produced FB-111A, General Dynamics gelled a proposal for a project known as the F-111G. This, too, was to have been a strategic bomber variant, though differing from its predecessors in that it was to have a substantially increased fuel capacity and a commensurately increased range; a bigger and more capacious bomb bay; more sophisticated avionics; more powerful engines; and greater overall dimensions. Unfortunately, due to the problems still plaguing the operational F-111s, the Air Force showed little interest in the program and it eventually died.

General Dynamics embarked on yet another F-111 bomber design shortly afterwards, this one epitomizing the program and representing the result of all the lessons learned during the F-111's development. Eventually known as the FB-111H, this airplane was to all intents and purposes a totally new design reminiscent of its predecessors in general external appearance only.

The FB-111H program had acquired its *raison d'etre* from the not-so-sudden realization that the result of the old AMSA program, the Rockwell International B-1A, might be in big financial trouble. The cost of the Rockwell program had been rising dramatically during the course of its development and there were growing fears in the Pentagon that eventually it might price itself right out of existence.

SAC FB-111A spreads its wings prior to takeoff from Offutt AFB. Airplane in photo is 69-6509. George Cockle photo.

General Dynamics was well aware of this situation (and a bit sympathetic!) and opted to continue in-house funding for a bomber F-111. Eventually, when the B-1 *did* price itself out of existence at over $100 million per airplane, the company was ready with a viable alternative.

The proposed FB-111H is a drastically improved airplane. Powered by two of the B1A's General Electric F101-GE-100 30,000-pound-thrust turbofans, it is fully capable of doing *almost* everything the B-1 can do, General Dynamics claims, at *less than half* the cost. In some areas the FB-111H is claimed to be even better than the B-1A. In navigational accuracy, for instance, the FB-111H's AJN-16/SKN-2400 navigation system is superior in capability to the B-1A's two AJN-17s. Additionally, the bombing and short range attack missile delivery capability of the FB-111H is also stated to be as good as or superior to that of the B-1A.

The proposed FB-111H also stacks up well in other departments: the radar system, consisting of an APQ-144(M), an APQ-134(M), an APN-200, and an APN-194, is every bit as good as the APN-144(M), the APZ-146(M), the APN-200, and the APN-194 unit in the B-1A.

The airplanes have similar capabilities in digital computers, multiplex converters, and global positioning systems.

In fact, the only areas in which the FB-111H comes up short are in overall unrefueled range and gross weapons-carrying ability. It is argued that the former is not particularly important due to the airplane's inflight refueling capability; and the latter can be discounted because although it takes two FB-111Hs to carry the B-1A's bomb load, the two airplanes are less than half as expensive and create twice the targeting difficulties for the enemy.

To give some idea of the extent of the physical changes between the standard FB-111A and FB-111H, take a look at the following specifications.

	FB-111A	FB-111H
Length	75'5.6"	88'2.5"
Span		
Extended	70'0"	70'0"
Swept	33'11"	44'10"
Height	17'0.5"	22'0"

The FB-111H's physical differences also include an empty weight of 51,832 pounds, a maximum gross takeoff weight of 140,000 pounds, and an internal fuel capacity of 64,574 pounds.

It is important to note that in light of its predecessors' intake problems the FB-111H incorporates a totally redesigned, advanced technology, fixed-geometry intake that is both uncomplicated and, based on wind tunnel tests, completely trouble free. The final configuration of this intake has been illustrated as a round, somewhat teardrop shaped design. Earlier FB-111H intake configurations were more rectangular in cross-

Transient FB-111As head for Offutt AFB's main runway in preparation for takeoff. George Cockle photo.

Perhaps the most interesting of the 76 FB-111As built was the eighth airplane, shown here. Following nearly three years of inaction and two years of rebuilding, it was returned to SAC service in late 1980. Two FB-111As were actually used in the rebuilding process. One had been damaged and burned after crashing into a light standard at Pease AFB. The other was number eight which was used for test purposes and which was never converted to a tactical machine. About 6,000 parts had to be made in restoring the aircraft to operational capability. General Dynamics photo.

Complexity of F-111 wing is readily apparent in this photo. Not only is it capable of variable geometry, but it also has leading and trailing edge high lift devices. Trailing edge flap is full span (roll control is via spoilers, in this position). The wing also contains fuel tanks and pylon alignment mechanisms! Author's collection.

section and of the conventional F-14/F-15 ramp format.

As of the date of this book, the FB-111H program (or a derivative thereof) is still in limbo. Though significant support for funding has been forthcoming from various government agencies, firm support has not yet developed and the likelihood of a production contract is dwindling. Additionally, a strong movement is once again afoot in the Air Force to develop a totally new B-52 replacement.

AN ELECTRONIC REBIRTH

What will likely become the last important F-111 program to see operational service is not a weapons delivery vehicle at all. In fact, it will carry no destructive weapons of any kind.

Modern warfare demands a number of unique capabilities, not the least of which is an ability to deal with the various passive and active electromagnetic emissions of enemy aircraft and ground-based missile track and search systems. Falling under the category of electronic countermeasures, or ECM, the objective is to screen attacking allied strike forces by continuously jamming all the electronic air defense elements along the attacking force's flight path, thus causing confusion, delays, and loss of enemy defensive systems effectiveness.

Vietnam proved the legitimacy of this concept. EB-66s, EA-6s, and a number of other types were used continuously throughout the conflict, proving that the electronic warfare scenario is both real and, from a capability standpoint, necessary.

But there were failings in each of the available systems. The EB-66 was old, slow, and rather short-legged; the EA-6 was limited by internal volume and nominal range; and the various other types of ECM transport aircraft were either temporary modifications or totally unsuitable for the job.

So the Air Force, in order to fulfill its own jamming requirements, began a low-priority program to determine which if any of the available operational types might best be suited for a tactical ECM mission. Among the top contenders was the General Dynamics F-111, which, eventually was determined to be the best of the aircraft examined. The F-111 offered solutions to each of the mission's basic problems: it was fast, it was relatively new, it had exceptional range and loiter capability, it had expansive internal volume, and best of all, it was readily available.

The latter point was particularly inviting. Most of the F-111Ds were still suffering from Mk.II avionics problems, and several other models were beginning to accumulate a significant number of airframe hours. These aircraft were particularly ripe for refurbishment and reconfiguration. This would play an important role in the decision to proceed with what would soon become the EF-111A program.

In mid-1974 General Dynamics and Grumman were awarded design study contracts to allow them to develop the best approach to the Electronic Countermeasures F-111. These studies were conducted throughout the rest of the year and resulted in a firm contract in January 1975 for $85.9 million to modify and test fly two existing F-111A aircraft as the EF-111A testbeds.

The first airplane was completed in late April 1977 and flown for the first time the following March 10. Primarily an aerodynamic testbed, it did not incorporate the full ECM suit and lacked a number of major external modifications that would later be tested on prototype number two. In fact, the only discernible external difference between the EF-111A prototype and a standard F-111A was a 16-foot-long canoe-shaped radome mounted under the fuselage approximately where the F-111A's bomb bay is normally located.

EF-111A number two, the first to incorporate most of the proposed production F-111A's jamming equipment, took to the air from Grumman's Calverton, Long Island facility on May 17, 1977. This airplane had the full AN/ALQ-99E ECM System (similar in most respects to the system carried by Grumman's successful EA-6B), the AN/ALZ-137 Self Protection System, and a modified AN/ALR-62 Terminal Threat Warning System. Perhaps the biggest external difference between this airplane and prototype number one was the addition of a large fin tip pod (similar to that seen on EA-6Bs) that houses various receiver antennas.

The EF-111A is the only tactical jamming aircraft that can provide coverage throughout the entire spectrum of tactical missions, ranging more than 2,000 miles or

Belly shot of second prototype EF-111A gives a good view of this model's distinctive antenna canoe In this photo the airplane was still in its original Grumman paint scheme. It has since been repainted. Grumman photo.

Over-view of EF-111A prototype shows airplane's unusual light grey scheme and miscellaneous antenna mods. George Cockle photo.

loitering for standoff jamming longer than any other ECM aircraft. Also, unlike other dedicated ECM aircraft, it can fly deep into and out of enemy territory along with the supersonic aircraft it is protecting.

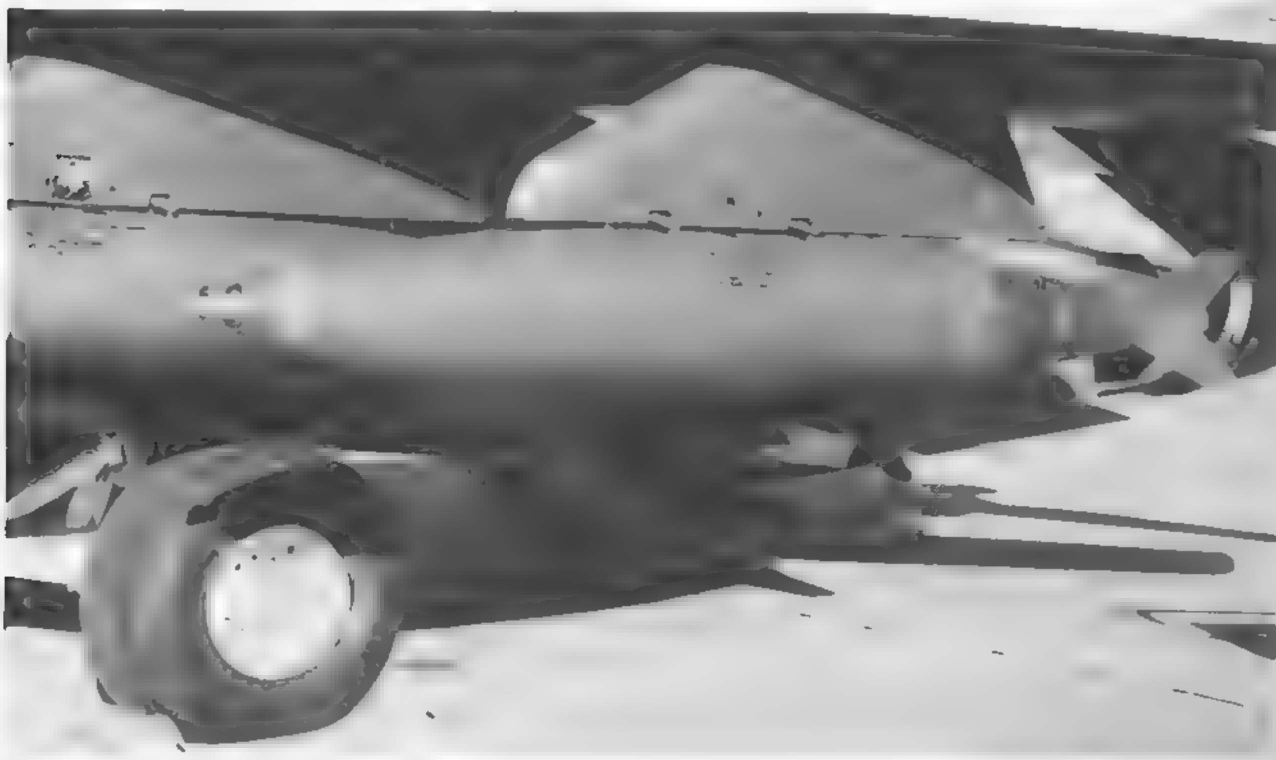
The EF-111A is expected to remain a viable investment over the planned 35-year operating life of its airframe. Interestingly, through sound engineering practices by Grumman and some advances in electronic warfare technology, the system has come through development with a 25 percent reserve in computer data-handling capacity. This is a significant growth factor that underscores the EF-111A's ability to cope with new and more sophisticated threat radars that may emerge in the future.

In early 1978, the two prototype EF-111As completed a 38-month development program at Grumman and at Air Force facilities. Grumman flight testing of the jamming system over a three-and-a-half-month period involved 84 flights and 215 flight hours. A total of 78 flights (258 flight hours) were made by Air Force teams to complete a rigorous six-month evaluation program on schedule.

The USAF-conducted tests verified various mission operational concepts, flight formations, and the jammer's electromagnetic compatibility with other strike aircraft (dispelling an earlier concern that they, as well as enemy threats, might possibly be jammed by the EF-111A's powerful signals). In addition, structural flight tests under all operating conditions demonstrated an "infinite" life for all modified areas of the aircraft. Flying qualities were deemed virtually identical to those of the standard F-111A.

The performance of the jamming system has been termed outstanding by observers. Tests of the EF-111A system in a most realistic, simulated Eastern European air-defense environment of the densest sort demonstrated its ability to detect and automatically assign jammers to every type of threat radar encountered. Not only did the system's jamming performance exceed all expectations, but also its reliability was found to be exceptional.

The prototype development has been completed, and the Defense Department has reviewed the program and agreed to the procurement of 40 EF-111A aircraft. Stock F-111A (and possibly some F-111Ds) from the current operational inventory will be removed and transferred to Grumman where a complete overhaul and modification



Virtually all operational aircraft-borne tactical rockets and bombs are capable of being launched or dropped from the F-111's weapons bay or wing pylons. Shown are two Mk.84 Mod. 1 free falling iron bombs mounted on an F-111D's wing pylons These pylons are articulated and are always parallel to the slipstream no matter what position the variable sweep wing is in. Author's collection.

program will be undertaken. The first "production" EF-111A is expected to be delivered to the Air Force by the end of 1981.

END OF THE LINE

In November 1976, the 562nd and last F-111 was completed by General Dynamics Fort Worth. This was an F-111F, Air Force serial number 74-00188. Several days later, this airplane departed Carswell AFB and headed skyward on its first test hop. It was a faultless mission, the product of many, many lessons—and in its own way a Phoenix rising from the ashes of an ignominious past.

AIRCRAFT DELIVERED UNDER CONTRACT NO.

MDS	R&D	PRODUCTION					TOTAL
	8260	13403	1130A	1130B	0630	0369	
F-111A	18*	141					159
F-111B	5	2					7
F-111C		24					24
F-111D		96					96
F-111E		94					94
F-111F		58					106
FB-111A		76	12	12	12	12	76*
TOTAL	23	491	12	12	12	12	562

*AF notes that one R&D F-111A accepted as FB-111A, total FB-111A then 77

Prototype FB-111A tests inflight refueling ability External tanks give airplane near-4,000 miles maximum range Pilots claim F-111 to be relatively easy to maneuver during refueling. General Dynamics photo.

F-111 VARIANT SPECIFICATIONS									
MODEL	LENGTH	SPAN (ext/swpt)	HEIGHT	EMPTY WEIGHT	GROSS WEIGHT	MAX. SPEED	MAX. ALTITUDE	FERRY RANGE	POWER PLANT PRATT & WHITNEY TF30-P-
F-111A	73'6"	63 0"/31'11 4"	17'1 4"	45,200 lbs	92,500 lbs	Mach 2 3	66,000'	3,800 mi	1/3
RF-111A	73 6'	63 0"/31'11 4"	17 1 4"	45,200 lbs	92 500 lbs.	Mach 2 3	66,000'	3,800 mi	3
F-111B	66'9'	70 0 '/33 11"	15 9	46 112 lbs	79,000 lbs	Mach 2 2	65 000 *	3 200 mi	3/12A
F-111C	73'6"	70'0 '/33 11"	17'1 4'	47 300 lbs	114,300 lbs	Mach 2 4	66 000	3,700 mi	3
F-111D	73'6"	63'0 '/31 11 4	17'1 4"	46 900 lbs	92,500 lbs	Mach 2.5	66,000'	3,700 mi	9
F 111E	73'6'	63 0' /31 11 4	17 1 4'	45 700 lbs	92,500 lbs	Mach 2 5	66 000'	3 700 mi	3
F-111F	73 6	63'0 /31'11 4"	17 1 4	47 200 lbs	100,000 lbs	Mach 2 5	66 000'	3,700 mi	100
FB-111A	75 6'	70'0 /33'11"	17'1 4"	47 500 lbs	114 300 lbs	Mach 2 2	66,000'	3,500 mi	7
FB-111H	88 2 5'	70 0' /44'10 2"	22'0"	51 832 lbs	140,000 lbs	Mach 2 5	65 000'	4,000 mi	F100
EF-111A	73'6"	63 0"/31'11 4"	17'1 4'	53 600 lbs	87,800 lbs	Mach 2 2	66.000'	3,800 mi	3

* Estimated

The F-111C was developed for Royal Australian Air Force use. It is basically an F-111A with F-111B wings. There are other modifications and changes as well. One of the first production aircraft, A8-126, is shown during its first flight. General Dynamics photo.

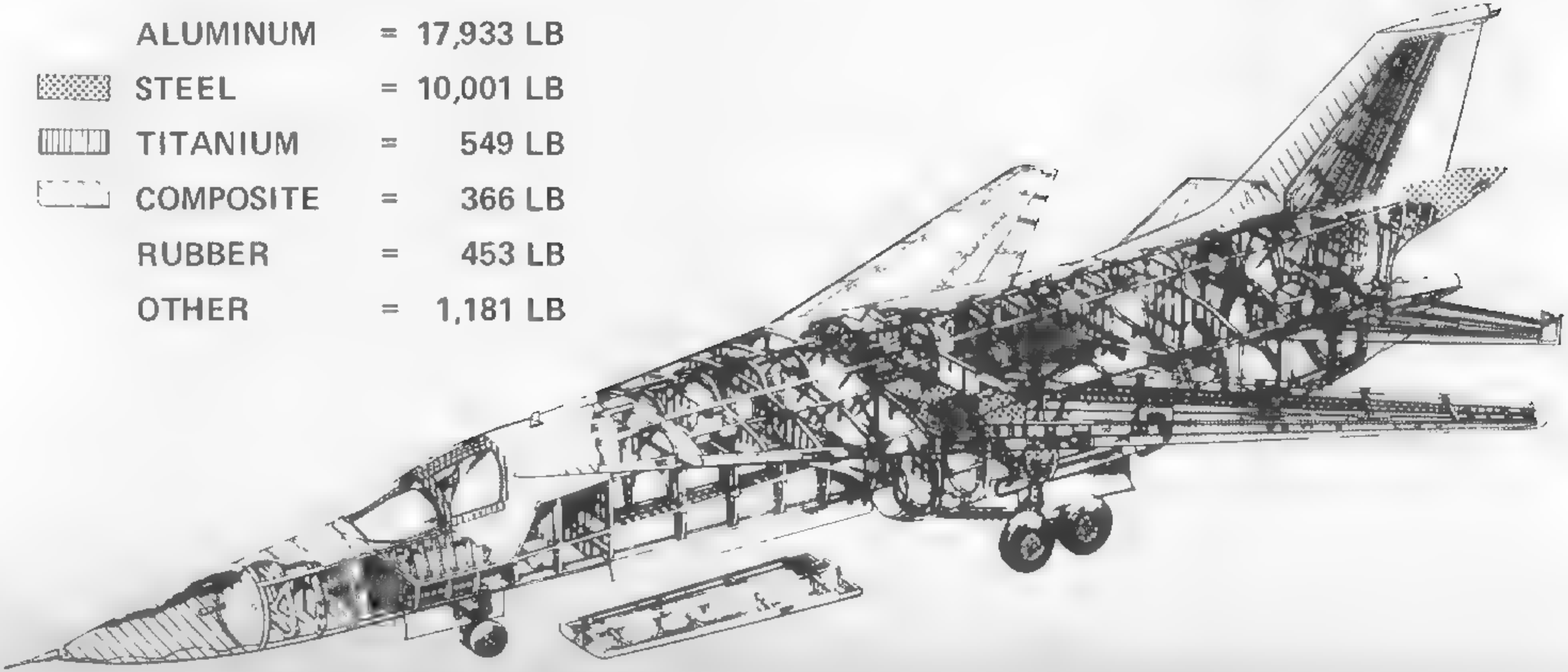
The prototype EF-111A dedicated electronic countermeasures transport took to the air for the first time on March 10, 1977. External differences were difficult to spot on this first sample as the only major change was an antenna canoe mounted just under the fuselage center section and bomb bay areas. Gumman photo.

Second prototype EF-111A, 66-041, illustrates definitive configuration of production variant. External modifications are almost as numerous as internal. Most noticeable of the former is the large fin-mounted radome. Other changes include numerous antennas, additional antenna radomes on the vertical fin, new dielectric paneling, redesigned slab stabilator root fairings (for additional sensors), and a distinctive grey paint scheme. Grumman photo.

Advanced FB-111 Structural Arrangement Material Distribution

STRUCTURAL WEIGHT	=	30,483 LBS
STRUCTURE IN COMMON WITH FB-111A/F-111F	=	43%

ALUMINUM	=	17,933 LB
STEEL	=	10,001 LB
TITANIUM	=	549 LB
COMPOSITE	=	366 LB
RUBBER	=	453 LB
OTHER	=	1,181 LB



Though originally designed for the air defence role, the F-111 has, in fact, rarely been used as an interceptor/dog fighter. Photo illustrates an early F-111A mounting two AIM-9 Sidewinder air-to-air missiles on its bomb bay rack during early tests. Note cameras mounted just under nose and wing tips. General Dynamics photo.

Belly shot of F-111B during flight test over Long Island. Note that wing tips stretch to just past the tips of the slab stabilators; compare this to similar shots of the Air Force versions and it will be noted that the wing tips of the latter are substantially shorter. Grumman photo via Jim Stevenson.

various armament options; free falling iron bombs, nuclear weapons, and sidewinders.

View of F-111D during refueling hook-up Boom has locked in to receptacle and the airplane is taking on fuel Several thousand pounds per minute can be transferred It is not necessary to fly straight and level in order to refuel. Author's collection.

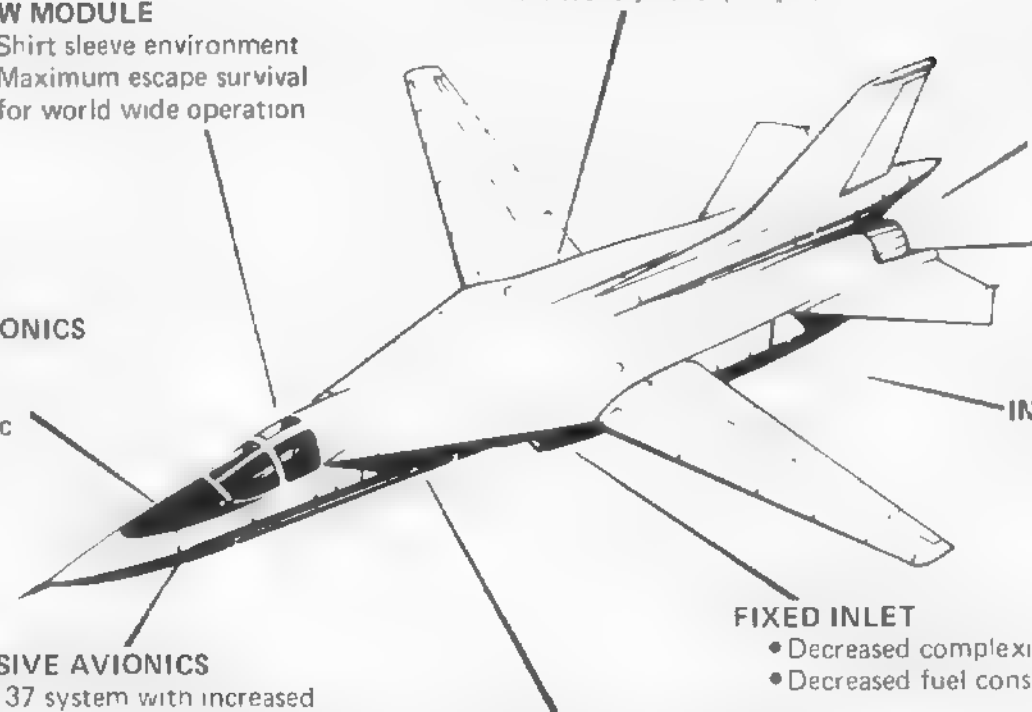
Somewhat unusual markings are found on Cannon AFB's 68-164. Note stars on main and nose gear covers. Lee Bracken photo.

View of Cannon AFB F-111D taken during refueling exercise over New Mexico. Refueling aircraft was Boeing KC-135A from Carswell AFB, Texas. Author's collection.

Stock Upper Heyford F-111E gives good view of British-based aircraft tail code. Airplane in photo is 68-0003. Brian Gardner photo.

View of 68-028, an F-111E painted in bicentennial markings and assigned to Upper Heyford, England. Chris Pocock photo.

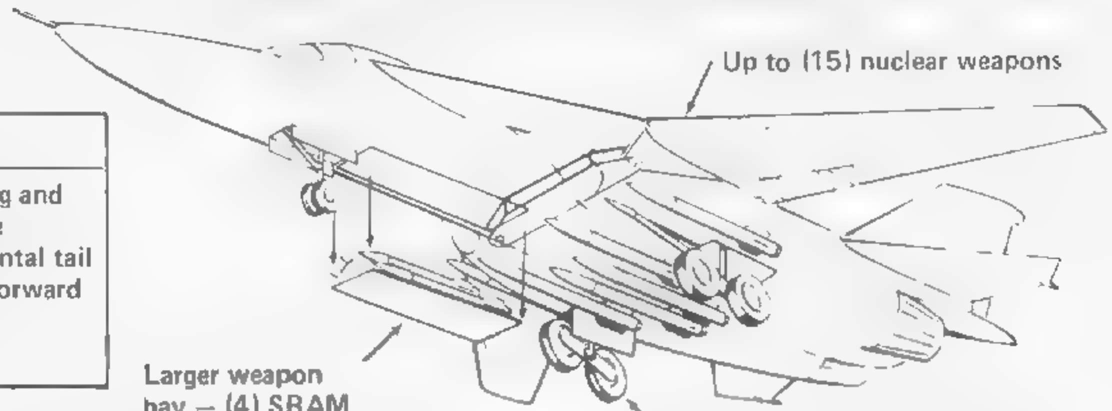
Major Features of the Advanced FB-111



The Advanced FB-111 is a New Weapon System Evolved From a Proven System

GREATLY IMPROVED AIRPLANE PERFORMANCE

INCREASED WEAPON CARRIAGE CAPABILITY



PROVEN FB-111A

- Variable sweep wing and carry-thru structure
- Vertical and horizontal tail
- Crew module and forward fuselage
- 75% of subsystems

SUBSYSTEM UPGRADING AND GROWTH

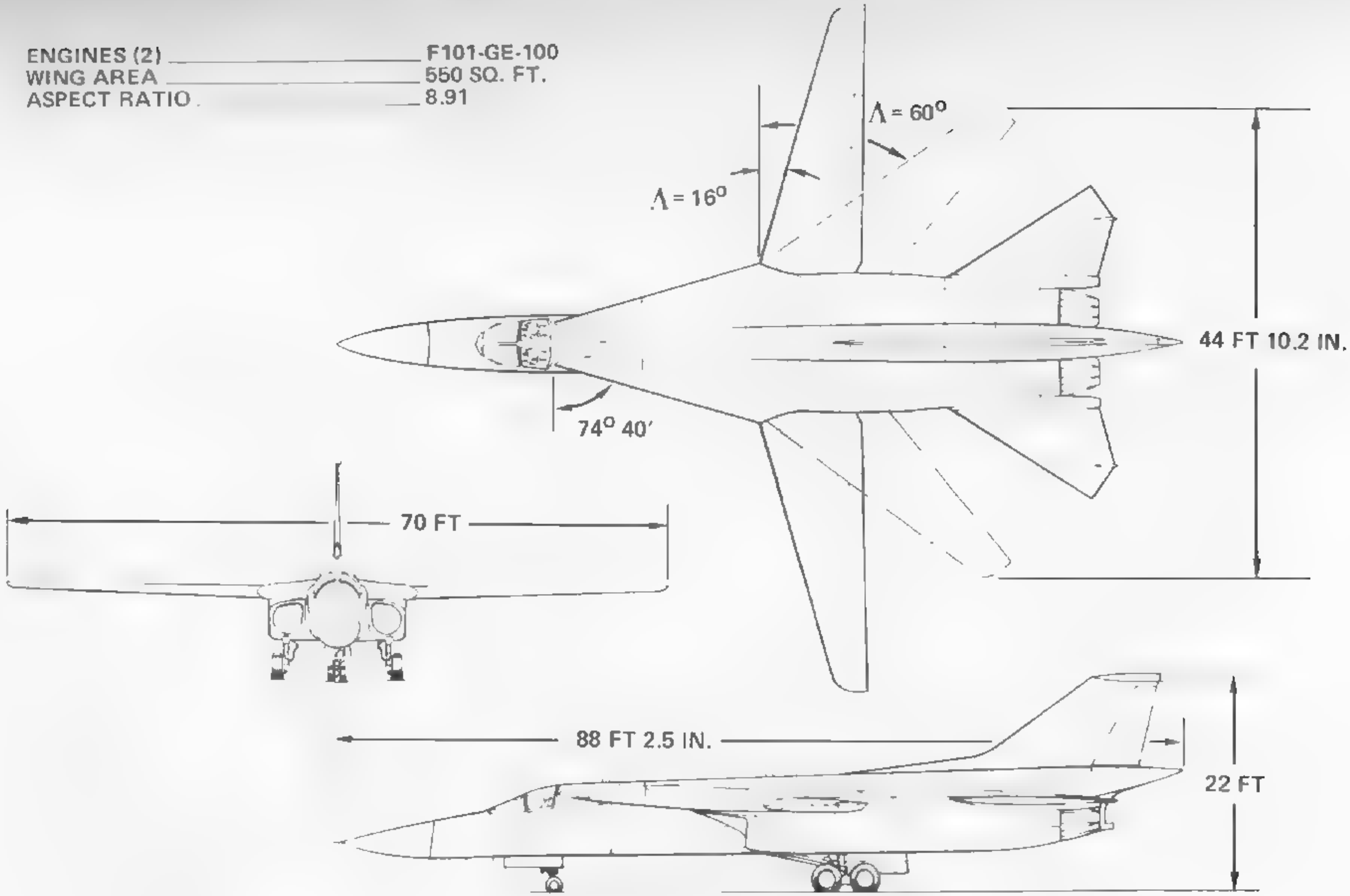
IMPROVED OFFENSIVE AVIONICS:
- Attitude reference in 35 sec.
- Back up INS

IMPROVED DEFENSIVE AVIONICS:
- Increased and expanded ECM coverage
- Chaff and flare capacity doubled
- Very low radar cross-section ($2.15M^2$)

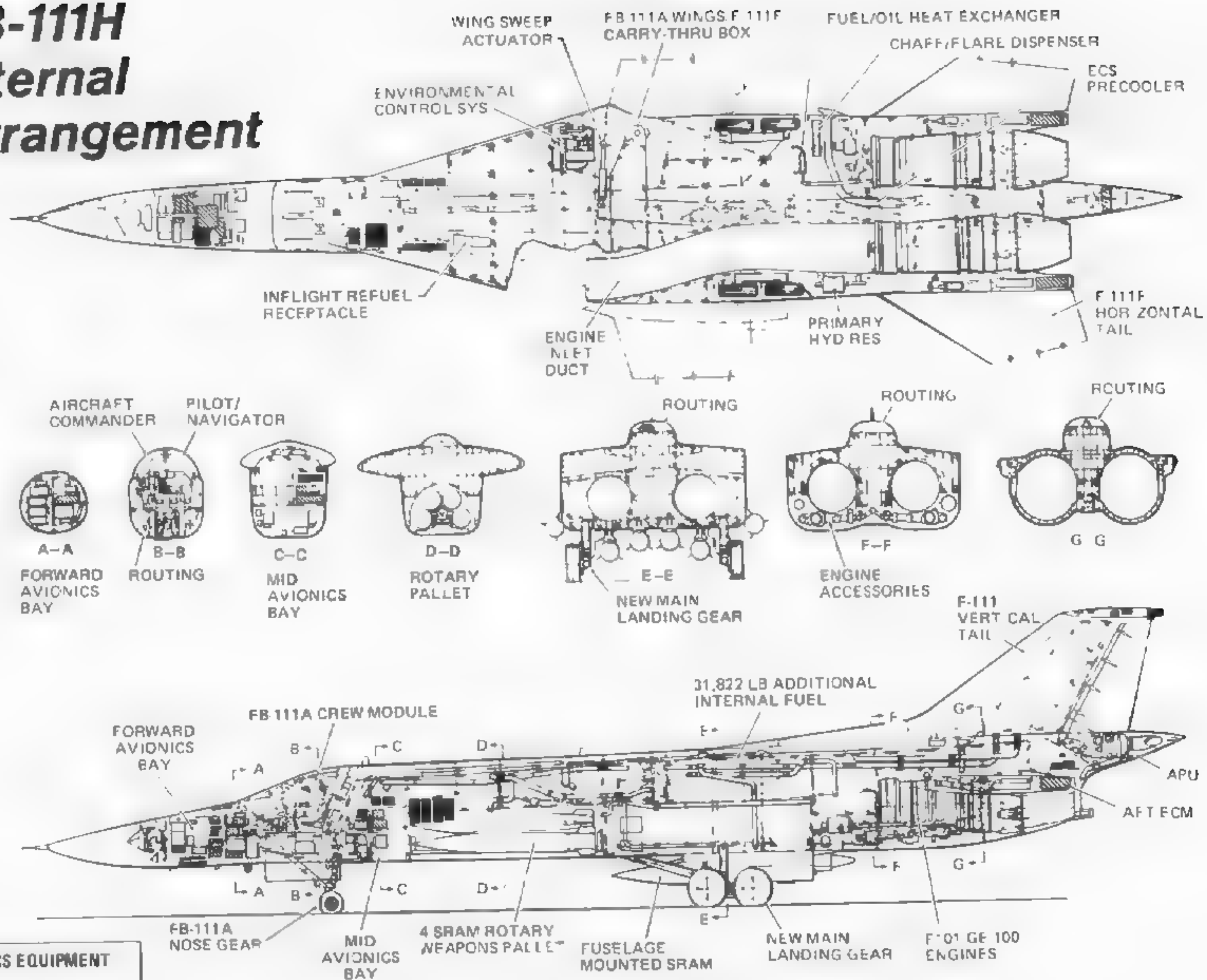
GROWTH PROVISIONS ARE INCORPORATED:
- Internal volume
- Power
- Cooling capability

FB-111H General Arrangement

ENGINES (2)	F101-GE-100
WING AREA	550 SQ. FT.
ASPECT RATIO	8.91



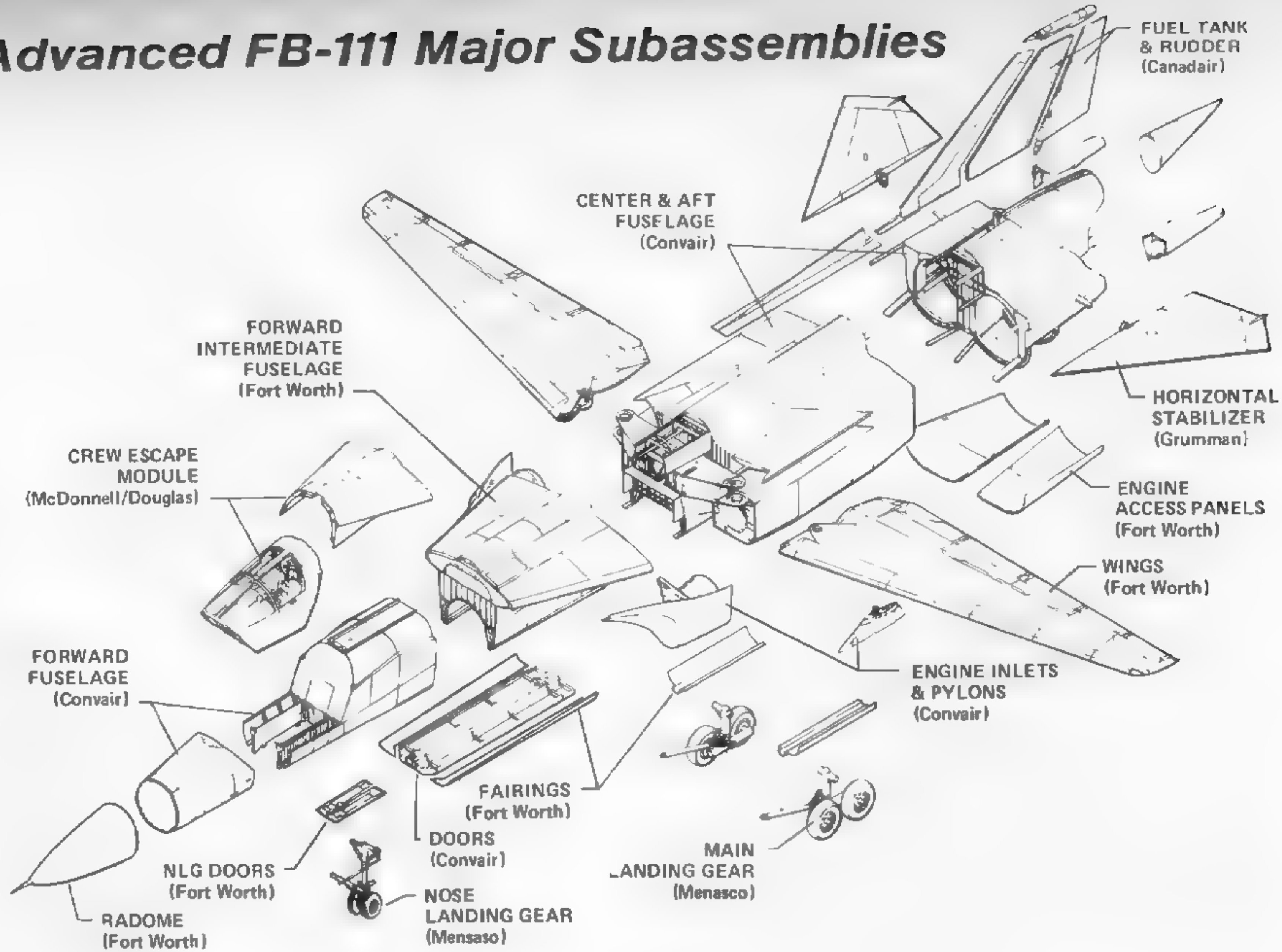
FB-111H Internal Arrangement

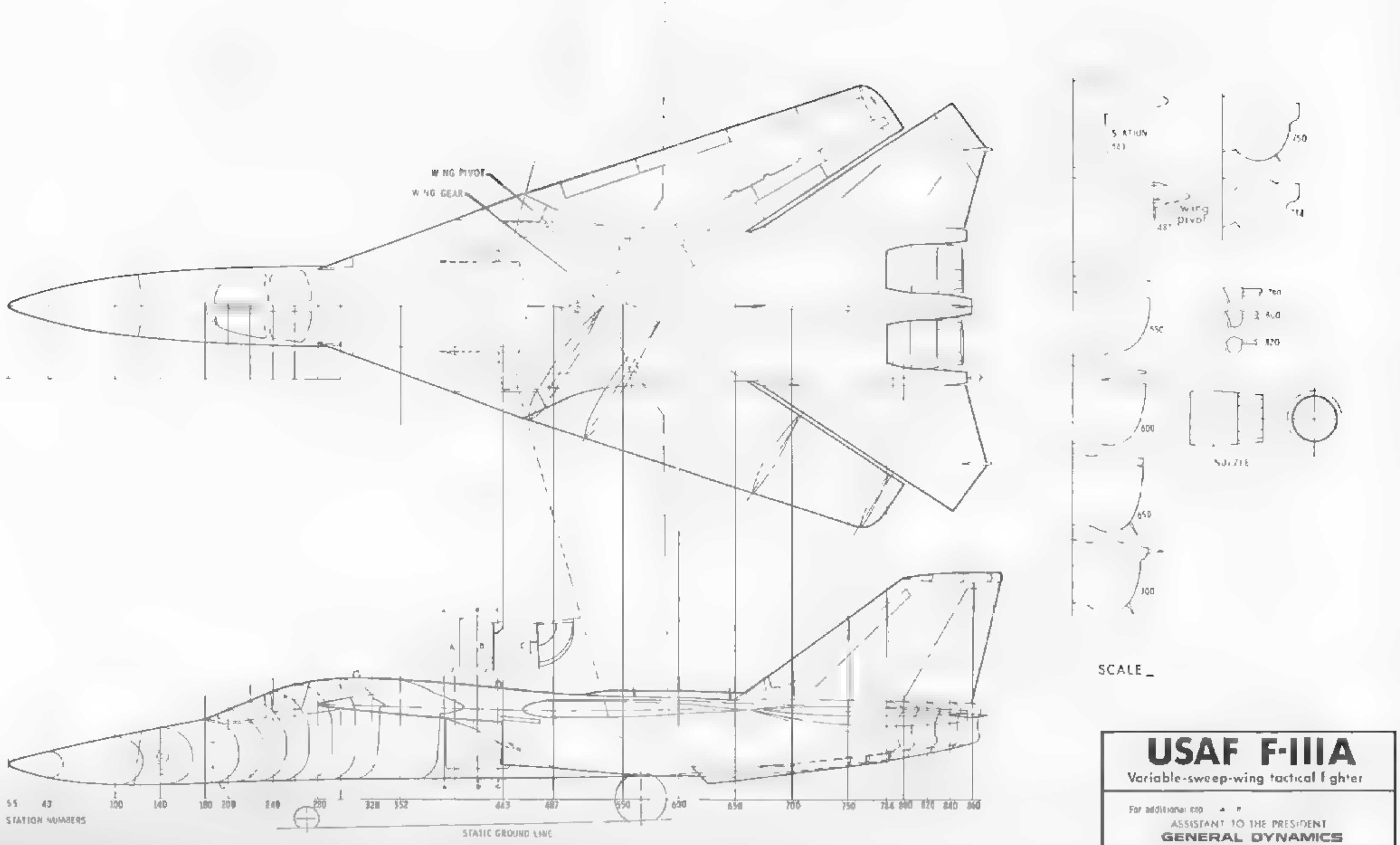


AVIONICS EQUIPMENT

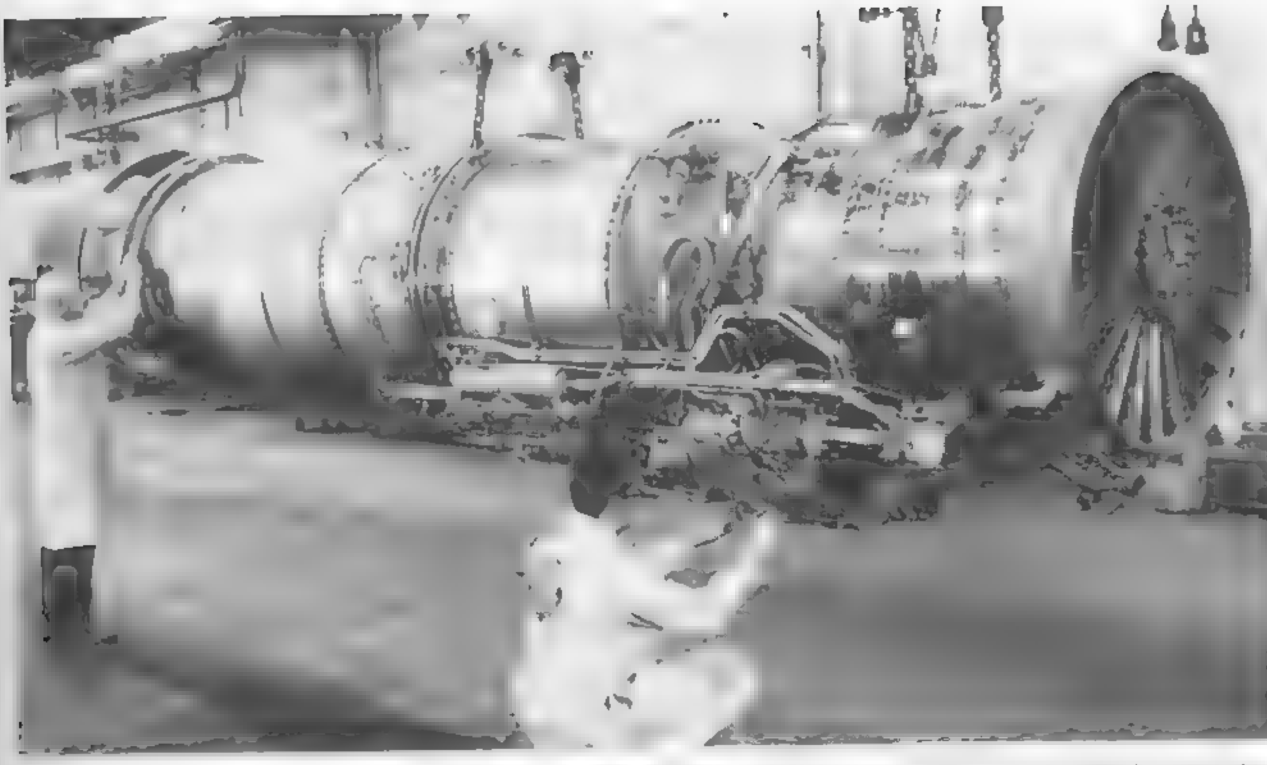
- FB-111A
- FB-111A UPDATE

Advanced FB-111 Major Subassemblies





Three-view drawing with sections of F-111A. General Dynamics photo.



The slightly improved TF30-P-3, shown here, is still found in many F-111As. Unfortunately like other TF30 powerplants, it has proven to be somewhat troublesome due to its susceptibility to compressor section stalls. Pratt & Whitney photo via General Dynamics.

THE PRATT & WHITNEY TF30 (Civil Designation: JTF10A)

The TF30 as used in the F-111 is a two-shaft axial-flow afterburning turbofan. It has a direct pitot annular type intake with 23 fixed inlet guide vanes. Hollow vanes are used to pass anti-icing air. The fan section consists of three stages. The rotor and stator sections with their associated casing are all titanium construction. Pressure ratio is 2.14:1 and the mass flow is typically 247 pounds per second (P-100 260 pounds per second.) The low pressure compressor section has six stages, and these are constructed integrally with the fan to form a nine-stage spool; construction is all titanium. The high pressure compressor section has seven stages; construction is primarily nickel-based alloy. The combustion chamber is of the can-annular type with steel casing and eight Hastelloy X flame cans. These are held at the front by four dual-orifice burners. The fuel system is a high-pressure type optimized for burning JP-4 or JP-5. There is a separate fuel system for the afterburner. The High Pressure turbine section is a single stage unit with 40 film-cooled nozzle guide vanes (stators) of cobalt-based alloy and 98 air-cooled rotor blades also of cobalt based alloy (P-100 vanes and blades are made of directionally solidified alloys). Gas temperature of a typical TF30 is 1,880 degrees F. Some variants, however, have gas temperatures of 2,300 degrees F. The low pressure turbine has three stages. Gas temperature after the turbine is typically 1,025 degrees F. The afterburner is a double wall outer duct type with an inner liner carrying a five zone combustion system. There are three spraybars and rings upstream from the flameholder. Fuel is supplied by a hydraulic pump at up to 4,000 pounds per hour. Above this level, fuel is supplied by a centrifugal afterburner pump. The exhaust nozzle of the afterburner has variable-area capability. This is provided by six hinged segments that are actuated by engine-fuel rams (the P-100 has 18 iris segments translated along a curved profile by six long-stroke rams). The ejector nozzle has six blow-in doors with free tail-feathers. Accessory drives are provided by a main gearbox under the compressor section of the engine. The engine lubrication system

is of the self-contained dry-sump, hot-tank type. The accessory gearbox housing forms a four-gallon tank. An air-turbine starter is provided on the left forward drive pad of the accessory gearbox.

The following table lists significant F-111 TF30 variants and their related civilian designations:

DESIGNATION		WEIGHT	MAXIMUM THRUST IN A/B
TF30-P-1	(JTF10A-20)	4,100 lbs.	18,500 lbs.
TF30-P-3	(JTF10A-21)	4,062 lbs.	18,500 lbs.
TF30-P-12	(JTF10A-27A)	4,000 lbs.	20,000+ lbs.
TF30-P-9	(JTF10A-36)	4,070 lbs.	19,600 lbs.
TF30-P-7	(JTF10A-27D)	4,121 lbs.	20,000+ lbs.
TF30-P-100	(JTF10A-32C)	3,900 lbs.	25,000+ lbs.

F-111A GENERAL DESCRIPTION

Type. Two-seat variable-geometry multi-purpose fighter-bomber.

Fuselage. Semi-monocoque structure, mainly of aluminum alloy, with honeycomb sandwich skin. Some structural members are of titanium and steel. Main structural member is a T-section keel, under the arms of which the twin TF30 turbofan engines are suspended.

Wings. Cantilever type mounted at shoulder position on fuselage. Wing section is NACA 63 series, with conventional washout. Sweepback of outer portions is hydraulically variable in flight or on the ground from 16 degrees to 72 degrees 30 minutes. Five-spar structure with stressed and sculptured skin panels, each made in one piece between leading and trailing edge sections, from root to tip. Leading and trailing edge sections of honeycomb sandwich. Airbrake/lift dumpers above wing operate also as spoilers for roll control at low speeds. Full-span variable-camber leading edge slats and full-span double slotted trailing edge flaps. General Electric—developed flight control system.

Tail Unit. Conventional cantilever swept surfaces. Utilizes honeycomb sandwich skin panels, except for tailplane tips and central area of fin on each side. All-moving horizontal slab-type stabilators operate differentially *and* symetrically for both high-speed roll control and pitch control at all speeds. Under the fuselage are two ventral fins for improved yaw control at high angles of attack.

Landing Gear. Hydraulically-retractable tricycle type. Single wheel and tire (47-18") on each main gear leg. Twin nose wheel that retracts forward. Main gear is a triangulated structure with hinged legs which are almost horizontal when the gear is extended. During retraction, the legs pivot downward, the wheels tilt to lie almost flat against them, and the whole gear rotates forward so that the wheels are stowed side by side inside the fuselage between the two engine air intake ducts. Disc brakes with an anti-skid system

Frontal view of F-111A with wings extended illustrates this model's unique wing root rotating gloves. Full span leading and trailing edge flaps are also readily apparent. Author's collection.

equip each main gear wheel. The main landing gear well cover, in the bottom of the fuselage, hinges downward to act as a speed brake in flight.

Accommodation. Crew of two side by side in an air-conditioned and pressurized cabin. Portion of canopy over each seat is hinged on aircraft center-line and opens upward for ingress and egress. Capsule has zero-speed, zero-altitude (including underwater) escape capability. It is powered during escape operations by a 40,000 pound thrust Rocket Power, Inc. rocket motor. Air-bags cushion impact of capsule and also form flotation gear in water. Entire capsule can be used for survival shelter, if necessary.

Armament. Various armament capabilities have been built into the various F-111 systems, but tactical fighter versions are capable of carrying one M-61A-1 cannon or two 750-pound iron bombs or one Mk.43 or one Mk.61 thermonuclear weapon in their respective weapons bays. External stores can be carried on four attachments under each wing. The two inboard pylons on each side pivot as the wings sweep back, to keep the stores parallel with the fuselage. The two outboard pylons on each wing are jettisonable and non-swivelling.

Miscellaneous. Various subcontractors besides those already mentioned include: General Electric Company for attack radars, flight control systems, and portions of the armament system; Westinghouse Electric Corporation for electrical generating systems; Litton Industries for the navigation and attack systems and astrocompass; Sanders Associates for the electronic countermeasures group; Avco Corporation for countermeasures receiving sets; Navigation and Control Division of Bendix Corporation for air data computer units; Collins Radio for high-frequency radio and antenna coupler; AiResearch Manufacturing Company for air-conditioning and pressurization equipment; Texas Instruments for terrain-following radar; GPL Division of General Precision, Incorporated for Doppler radar; Motorola for X-band transponder; Honeywell for the low-altitude radar altimeter; Textron for the radar homing and warning system; and Autonetics Division of Rockwell International for the Mk.II/IIB avionics.

Unusual underside view of EF-111A prototype shortly after takeoff. Antenna "canoe" is readily visible. George Cockle photo.

Inflight of 66-041 shows configuration of airplane in cruise condition Note partially swept wings and antenna "canoe." Grumman photo.

F-111 CHRONOLOGY

1960

April

General Dynamics begins studies at Forth Worth on short takeoff-landing aircraft designs.

1961

July

General Dynamics and Grumman Aircraft Engineering Corporation join forces for bi-service aircraft proposal.

September 1

Department of Defense (DOD) announces new USAF/USN tactical fighter program (TFX).

December 6

Six leading aircraft manufacturers submit first bi-service tactical fighter proposals to DOD.

1962

January 31

DOD selects two manufacturers as finalists.

November 24

DOD names General Dynamics prime contractor for F-111, with Grumman as principal subcontractor, for 23 development aircraft (18 for Air Force, 5 for Navy).

1963

September

F-111 tooling begins.

October 24

DOD announces Australian government order of 24 F-111s.

Aft fuselage of EF-111A incorporates the majority of the major visible external modifications. Note antenna housing on top of vertical fin—and additional antenna fairings on main fin surface. Additionally, slab stabilator fairing has also been modified to incorporate passive sensors. George Cockle photo.

Four F-111Cs have been converted to photo reconnaissance platforms by General Dynamics under a contract with the Australian government. Both optical and electronic sensors are fitted. Recce systems bay is visible in photo of this first conversion. General Dynamics photo.

[redacted]

October 15
First F-111 rolls out 16 days ahead of schedule.

December 21
First F-111 flies 10 days ahead of schedule.

1965

January 6
First F-111 in-flight demonstration of variable sweep wing use 24 days ahead of schedule.

February 25
Second F-111 flies three days ahead of schedule.

1965

March 5
First supersonic flight (Mach 1.2) demonstration made by first F-111.

April 12
DOD announces letter contract with General Dynamics for 431 production F-111s (407 for Air Force, 24 for Navy) at a figure "in excess of $1.5 billion."

April 30
F-111A No. 3 makes first flight on schedule.

May 2
F-111A No. 2 is first to fly to Edwards Air Force Base, California, to begin extensive flight test program.

May 10
Lt. Col. James W. Wood pilots F-111 at Edwards AFB to become first Air Force officer to fly F-111.

May 11
F-111B, first Navy-version F-111, rolls out ahead of schedule at Peconic Airport, Long Island, facility of General Dynamics' associate and principal subcontractor, Grumman Aircraft Engineering Corporation.

May 18
First Navy-version F-111B flies 13 days ahead of schedule at Peconic Airport. Flight termed highly successful.

Late production FB-111A, 68-272, is seen at Edwards AFB during systems tests. Author's collection.

June 29
F-111A No. 4 makes first flight one day ahead of schedule.

July 27
Capt. D. C. Davis, USN, in flight at Edwards AFB, becomes first Navy pilot to fly F-111.

July 31
F-111A No. 5 makes first flight on schedule.

October 8
Gr. Capt. C. H. Spurgeon of the Royal Australian Air Force pilots F-111 at Fort Worth to become first pilot of a foreign nation to fly F-111.

October 19
Sixth Air Force F-111A makes first flight 12 days ahead of schedule.

October 24
Second Navy-version F-111B makes first flight seven days ahead of schedule at Peconic.

October 25
F-111A No. 5 is first F-111 to fly to Eglin Air Force Base, Florida, to begin extensive flight testing of its electronic and environmental systems.

December 3
DOD authorizes General Dynamics to develop RF-111A, a reconnaissance version of the F-111.

December 10
DOD discloses plans for 210 FB-111s, a new Air Force strategic bomber incorporating basic design of the F-111.

December 16
Wing Comdr. G. R. K. Fletcher pilots F-111 at Fort Worth to become first Royal Air Force pilot to fly aircraft.

December 21
Third Navy F-111B makes first flight at Peconic.

December 24
Seventh Air Force F-111A makes first flight seven days ahead of schedule.

December 30
Eighth F-111A, the first airplane scheduled for Air Force Category II flight testing, makes first flight one day ahead of schedule.

Twenty of the twenty-four F-111Cs eventually delivered to the RAAF are shown in storage at General Dynamics Fort Worth facility. Initially, the aircraft were stored outdoors. When it was learned that the storage program might be long-term, the aircraft were moved indoors and more effectively protected from the elements. General Dynamics photo.

1966

January 18
Wing Commander G. R. K. Fletcher, Royal Air Force, utilizes F-111's terrain-following radar during two-hour flight at Edwards AFB.

January 24
F-111s pass 500th flight hour mark.

January 29
Ninth F-111A makes first flight two days ahead of schedule.

February 22
British government makes public its decision for an initial order of 10 F-111s, to be followed by an additional 40 aircraft.

February 28
Tenth F-111A makes first flight on schedule. Is 13th F-111 program aircraft to take to the air (10 F-111As and 3 F-111Bs).

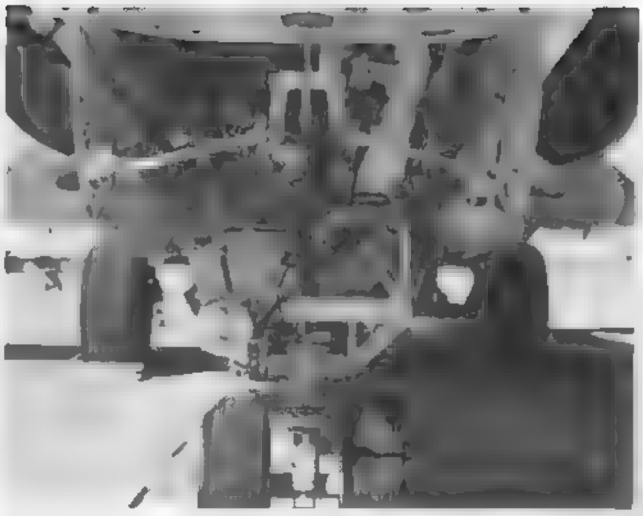
February 28
F-111s pass 600th flight hour mark and record 400th flight in flight log.

March 3
F-111A No. 1 makes first of a series of low-level supersonic flight demonstrations through test corridor over Gulf of Mexico.

March 4
Maj. Gen. John L. Zoeckler issues commendation pointing up 14 months of accident-free F-111 flight testing at Fort Worth, at Edwards AFB, at Eglin AFB, and at Peconic.

March 5
F-111A No. 9 makes ferry flight from Fort Worth to Edwards AFB to become second F-111 in Air Force Category II flight test program.

Nose gear detail illustrates complexity of unit and offset retraction ram (on right). Gear retracts forward. Author's collection.



Cockpit of FB-111A. Instrumentation is densely packed on panel. Both crew stations are equipped with full control compliment. Right crew station is usually utilized for weapon system control. Author's collection.

March 9
F-111A No. 1 makes its 100th flight.

March 15
The F-111 contract was amended to provide for 50 F-111s for the Royal Air Force.

April
The terrain-following radar equipment for the F-111 successfully completed its reliability qualification test at Texas Instruments, Inc., Dallas, Texas.

May 28
Negotiations are completed for 493 F-111s, consisting of 469 F-111As and 24 F-111Bs. Of the 469 F-111As, 24 will go to Australia, 50 are to be designated F-111K for the British and 64 are to be designated FB-111 for the Strategic Air Command.

December
The last of the Research, Development, Test and Evaluation aircraft is accepted. Sixteen of the 18 Air Force and all 5 Navy versions are in the flight test program. One Air Force plane is set aside as prototype for RF-111 and one for prototype of FB-111.

1967

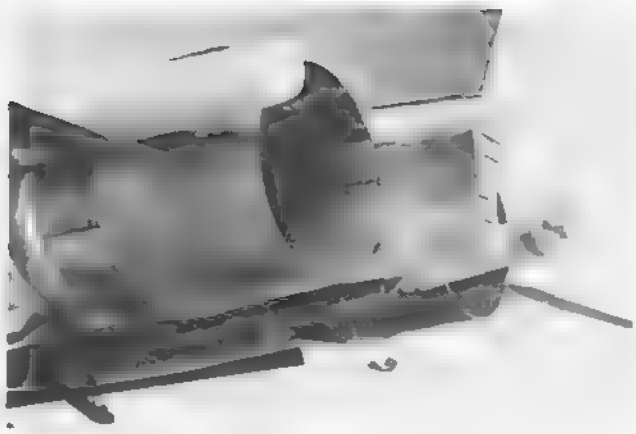
April
Parachute recovery system for the F-111 crew module is tested successfully over the California desert.

May 10
Air Force announces a definitive contract for the production of 493 F-111s.

May 22
Transatlantic range is demonstrated when the F-111 becomes the first tactical aircraft to fly from the United States to Europe without external tanks or in-flight refueling.

July 17
First F-111As are deployed to Nellis AFB, Nevada, where the Tactical Air Command initiates operational testing and training.

The first RAAF RF-111C heads skyward from Fort Worth for the long trip to Australia. Each of the remaining three RF-111C conversions for the RAAF will be completed in Australia by RAAF personnel General Dynamics photo.



***F-111A tail section detail illustrates free floating** tail feathers of TF30 afterburners, blunted tips of speed fairings (which house tail warning devices and electronic countermeasures equipment), and fuel dump nozzle (between engine exhausts at base of empennage section). Author's collection.*

1967

July 30

First flight of FB-111 prototype.

October 4

The F-111 crew module is successfully tested on the Air Force Missile Development Center test track, Holloman AFB, New Mexico.

October 14

The first gun firing at supersonic speed is accomplished during a weapons bay gun firing test conducted on F-111A No. 5.

October 16

First operationally configured production aircraft (F-111A No. 31) is delivered to Nellis AFB, Nevada.

[redacted]

February 29

Cancellation of British F-111K program. General Dynamics is directed to divert F-111K No. 1 and No. 2 to the F-111A program as test airplanes. Common assets of F-111Ks No. 3 through No. 50 are diverted to the FB-111 program.

March 17

F-111As arrive at Takhli Royal Thai Air Base, north of Bangkok, Thailand. The Air Force announces that the F-111s are to undergo operations and combat evaluations.

March 18

Announcement of the F-111E version. This version incorporates refined air inlets to improve engine performance at high speed and high altitude and during flight maneuvers.

March 25

F-111s fly first air strikes against North Vietnam.

July 13

The first production FB-111A is flown at Fort Worth.

August 30

First FB-111A contractually accepted by the Air Force.

September

U.S. Senator Howard Cannon flies an F-111 at Nellis AFB and praises it in an article, "The F-111—A Pilot's Report." He is a major general in the Air Force Reserve.

October 9

The Air Force announces that the safety record of the F-111 is better than most planes in the so-called Century series.

October 11

Prime Minister John Gorton of Australia says he is satisfied with the F-111Cs his country is buying. The F-111 receives a vote of confidence in the Australian House of Representatives.

October 26

Defense Secretary Clark Clifford calls the F-111 "an excellent airplane" and predicts that it will develop into "the most modern plane in the world today."

November 22

F-111As deployed to Thailand return to Nellis AFB. Air Force flight and ground crews on the aircraft are highly complimentary of the operational performance of the F-111As in Southeast Asia.

December 2

First flight of an F-111D prototype aircraft. The prototype is an F-111A modified to incorporate the Mark II advanced avionics system.

[illegible]

January 1

U.S. Senator Barry Goldwater flies an F-111A at Nellis and is impressed.

January 13

U. S. News and World Report, in its story "A New Appraisal of TFX by the Pilots Who Flew It," reports interviews with pilots who flew F-111As in Southeast Asia. The article states that the pilots to a man expressed amazement at the airplane's blind flight and bombing accuracy capabilities.

January 14

The 20,000th flight hour of the F-111 program is recorded.

January 20

The 10,000th F-111 flight is accomplished.

January 24

U.S. Senator Edmund Muskie, a member of the Senate Government Operations Committee, makes a one-hour flight in an F-111A at Fort Worth and states, "I'm impressed . . . I think it might not do any harm for the other members of the committee to take a ride."

April 17

F-111 is praised before the Senate Armed Services Committee by Air Force Secretary Robert C. Seamans and by Air Force Chief of Staff, Gen. John P. McConnell. Seamans states that the F-111's bombing accuracy, despite darkness or bad weather, is comparable to the daylight accuracy of other fighters in good weather. "Its great unrefueled range enables it to strike targets much deeper in enemy territory than an existing fighter and to perform extended all-weather armed reconnaissance." McConnell states that the F-111 "gives the tactical commander for the first time the capability to interdict an enemy round-the-clock in good weather or bad with increased range,

payload and accuracy . . . This aircraft should experience fewer losses from sophisticated defense and will be less dependent upon fighter escort and tanker support."

April 25

Flying magazine in its May issue says that the F-111 is both a demon weapon and a sweet-handling dream-ship and that the indictments against it are unjust and unwarranted. The magazine presents a "trial" of the F-111 and finds it innocent on five counts, says there are mitigating circumstances on a sixth count. A pilot report describes the F-111 as "better than any other aircraft so far."

April

The 13,000th flight and 30,000th flight hour are recorded the week of April 28.

May 8

Flying Review magazine, a British publication, joins the ranks of magazines praising the F-111. The article, by William Green, lists criticisms frequently heard about the F-111 and concludes that they "simply are not borne out by the facts."

July 10

Ten F-111As from Nellis AFB are temporarily assigned to Cannon AFB, New Mexico, to initiate F-111 activity at Cannon. Cannon is to receive F-111E aircraft and the F-111As are to return to Nellis.

August

Claude Witze, senior editor of *Air Force and Space Digest*, praises the Mark II avionics system of the F-111D as "the best ever delivered to the Air Force" in an article for the magazine.

August 20

Maj. Tom Wheeler, formerly chief of flight test and acceptance at General Dynamics Fort Worth Division, is quoted in an article in *Airman* magazine titled "The Fantastic F-111." Wheeler says: "When you can send a lone airplane from a base in Thailand to hit a target in North Vietnam . . . with more ordnance than you can hang on any other bird . . . against targets that it can bomb with great accuracy, no matter how black the night or foul the weather . . . and return, unrefueled, to its home base . . . you've got one helluva fine airplane." He added that the F-111 must be judged not on political consideration but on how well it can perform the mission it is assigned. "The F-111 is a fantastic airplane," he concludes.

September 12

The Air Force announces a new version of the F-111, the F-111F. This airplane is to have avionics simpler than that of the F-111D yet more advanced than those of the F-111A or the F-111E. It is to feature the TF30-P100 engine, which produces 25 percent more thrust than the basic TF-30. The Air Force does not say how many F-111Fs are to be built.

September 17

Air Force and Space Digest writes of the F-111s in combat in Southeast Asia, quoting Brig. Gen. John Chandler. The magazine concludes that the F-111 has proven in combat that it is operationally ready.

September 18

Australia announces in principle that it is ready to accept delivery of its 24 F-111C aircraft.

September 26

The Air Force announces that it will deploy F-111s to England in the spring of 1970. The F-111s are to replace F-100 aircraft.

October 8

The first FB-111A is formally delivered to the Strategic Air Command in ceremonies at Carswell AFB, Texas.

October 8

Gen. B. K. Holloway, Commander of the Strategic Air Command, officially accepts the first FB-111A (No. 7) into the SAC inventory during ceremonies held at Carswell. The aircraft is delivered to SAC.

October 17

The first flight in a production FB-111A aircraft with a SRAM test missile is successfully made by FB-111A No. 5.

November 7

Lt. Gen. David C. Jones, Comm. 2nd Air Force, became the first general officer to fly the 340th Bomb Group's FB-111A. His flight was made at General Dynamics Fort Worth.

December 5

The Australian government announces its intent to take delivery of its 24 F-111C aircraft which have been in storage at General Dynamics Fort Worth Division. Deliveries are scheduled to begin in the spring of 1970.

December 8

Announcement is made that the F-111 fleet has recorded its 50,000th hour of flight.

December 16

The first F-111C is placed in the post-delivery modernization program.

1970

February

The February issue of *Air Progress* magazine carries on its cover a color photo of an FB-111. The title of the article, in the Military Report section, is "FB-111A—First New Bomber in 10 Years." It states: "There's no lack of enthusiasm for the FB-111 . . . among its two-man crews—pilot and navigator-bombardier—now in training at Carswell Air Force Base." It adds: "Flying the FB-111 is a spine-tingling experience. And for a pilot, it also is a little like legalizing bank robbery. All through his career, the military pilot has been restrained by a very strict embargo on buzzing.

"But flying low and fast is just the thing to do in the FB-111, for that's its main technique in avoiding radar detection. It can even get a little hairy when, skimming over the sagebrush with the automatic terrain-following radar guiding the bird, you look up to find yourself on a collision course with a mountain peak. That's when you need a full measure of self-control to keep from grabbing the stick and overriding the autopilot.

"But when the plane skims neatly over the top with feet to spare, or banks gracefully off to the side, it's a great confidence builder for the pilots." Special praise is given to the plane's Mark II navigation and bombing system, which, the magazine says, "is so accurate that while traveling faster than 1200 mph, it can find its target or fly to a destination with an accuracy measured in feet."

March

Activity on the cold temperature proof test program begins at General Dynamics Fort Worth and Waco. Two hundred sixty-one aircraft are planned at Fort Worth with a maximum rate of one per day. The first airplane is scheduled for the cold-proof test on May 1, 1970, and the last aircraft is planned for completion during the first quarter of 1971.

It is planned to accomplish 57 airplanes at Waco, all of which are F-111As. The maximum output is to be one aircraft every three days with the first airplane scheduled for the cold-proof test fixture on June 1, 1970. Final de ivery from Waco is planned for February, 1971.

April 8

The first SRAM missile is successfully launched from FB-111A No. 5 over the White Sands Missile Range.

1970

April 30

F-111A No. 75, the first aircraft to enter the cold temperature (-40°) proof test program, is proof tested one day ahead of schedule.

May 20

A successful FB-111A/SRAM launch is accomplished at White Sands Missile Range. This is the second SRAM launch and it is a high altitude, long range ballistic trajectory.

June 30

The first F-111D is contractually accepted. The aircraft is to enter Category II flight testing at Edwards AFB in July after instrumentation checks are completed at Fort Worth.

September 12

The first two F-111E aircraft of a contemplated full wing are deployed to Upper Heyford, England, flying non-stop from Langley AFB, Virginia.

September 22

First launch of a SRAM missile from an aircraft flying at supersonic speed is accomplished from FB-111A No. 5 over White Sands Missile Range, New Mexico. The missile flies its programmed trajectory, completes all flight objectives and impacts on the range as planned.

November 15—20

FB-111As Nos. 17 and 18 from the 340th Bomb Group at Carswell AFB participate in the 1970 SAC Aircraft Combat Competition at McCoy AFB, Florida. FB No. 17 places second in overall bombing navigation. FB No. 18 places first in bombing mission. Competing aircraft include 23 B-52s, 27 KC-135s, 3 British Vulcans, and 2 FB-111As. (The FB-111As are not eligible for either the Saunders or Fairchild trophies since these awards include tanker scores.) The FB-111A avionics used in the two FB-111A airplanes entered in the SAC competition work exceptionally well. There are no removals caused by hardware failure during the period the airplanes are actively engaged in the competitive missions.

December 16

FB-111A No. 37 is transferred to Pease AFB, New Hampshire, the first FB to be assigned to the 309th Bomb Wing, 817th Air Division.Three FBs are delivered from Carswell AFB to Pease AFB during December.

1971

January 15

Facts not widely enough understood about the F-111 are assembled by the Commander of Air Force Systems Command, Gen. George S. Brown, to be given at a meeting at Bolling Air Force Base on January 14. States Brown: "The F-111 is *more advanced than anything even remotely similar in the world.* Even from our limited experience with them, I could certainly have used a wing or two of F-111s in Southeast Asia. *There is no other airplane in the world today as capable* of deep penetration against heavy defense and extreme target accuracy . . . "The F-111s have been well worth their cost, and it's really unfortunate that those costs have made it necessary to reduce the numbers we were able to buy, because these aircraft are making and will continue to make a very profound contribution to our national security posture.

"F-111 program stretchouts, changes in quantity from thousands to hundreds, up-and-down financing, a multiplicity of different models, inflation—all these things drove the price up. Yet, as I have pointed out, even at the higher price, we have actually bought one of the greatest airplanes flying today. And despite the sensational accident stories that have gotten so much attention, the F-111 has had a better history, a better safety record, than any of our Century-series fighters to date."

February

All buildings at the former Waco facility are completely cleared and closed during February.

March 3

Engineers at General Dynamics Fort Worth learn of the recent Los Angeles earthquake roughly 11 minutes after it happens, thanks to the F-111's ultrasensitive inertial navigation system.

"Our people were bench-testing an F-111 navigation system in the Specialized Repair Area when the quake hit some 1,200 miles away. "The navigation system picked up the first shock waves roughly 11 minutes after it happened."

April 1—6

Four F-111As from the 430th Tactical Fighter Squadron at Nellis AFB, Nevada participate in the Royal Australian Air Force's 50th anniversary celebration.

June 29

F-111E No. 87 of the 20th Tactical Fighter Wing credited with flying the 100,000th hour of F-111 flight time.

July 17

Plattsburgh AFB receives its first FB-111. Col. G. R. Abendhoff, Wing Commander of the 380th Strategic Aerospace Wing, ferries FB-111A No. 56 from Carswell AFB to Plattsburgh.

July 21

The second FB-111A is received by Plattsburgh with the transfer of FB-111A No. 54 from Carswell AFB.

July 29

The last five F-111E aircraft are deployed to Upper Heyford as scheduled. During 1971 and since the F-111Es began flying to the United Kingdom unrefueled, there has not been a deviation from scheduled time of departure or aircraft assigned for deployment.

July 30
The first Mark II—equipped airplane, F-111D No. 2 is delivered to the Air Force. This aircraft is being instrumented for climatic cold tests at Eglin AFB, Florida.

September 9
The last FB-111A departs from Carswell, terminating the combat crew training activity by the 340th Bomb Group.

September 9
(The 340th Bomb Group has accumulated 13,312 flight hours during 3,179 sorties since delivery of the first FB-111A in September 1969. All of the flight crew personnel of the 509th Bomb Wing, Pease AFB and the 380th Strategic Aerospace Wing, Plattsburgh AFB, were trained at Carswell. The combat crew training is now done at Plattsburgh.)

November 1
F-111D No. 6, contractually accepted October 28, is delivered to Col. C. E. Francis, Commander of the 27th Tactical Fighter Wing. Col. Francis flies the airplane back to Cannon AFB.

December 16
The Australian government states their decision to accept delivery of the 24 F-111C aircraft in a letter to our Deputy Secretary of Defense. The F-111C aircraft is to be put through a modification/refurbishment program prior to delivery to the RAAF.

December 28
The Supplemental Agreement that authorizes full go-ahead on F-111F 71–82 (12 follow-on) is received by General Dynamics.

1972

January 18
F-111A No. 36 (66-018) logs 1,000 flying hours at Nellis AFB. It is the first 111 aircraft to log 1,000 hours.

February 22
150,000 hours of flight time has been accumulated by F/FB-111 aircraft.

May 16
Operational readiness inspection of the 509th Bomb Wing at Pease AFB is completed. The wing receives a rating of outstanding.

June 9
An Operational Readiness Inspection was recently conducted at Plattsburgh AFB for the 380th Strategic Aerospace Wing. The ORI, which was the first for the FB-111A wing, is rated as satisfactory.

June 1
The F-111D Bomb-Navigation System maintenance trainer T-28 is accepted on May 26 and delivered to Cannon Air Force Base on June 1.

July 14
Fort Worth #1-3 Wing Carry Through Box fatigue testing has been successfully completed through Block 100, which is equivalent to 10 service lives or 40,000 flying hours.

September 28
First F-111s from Constant Guard V fly combat missions.

October 4
Daily F-111 combat activity briefings initiated for TAC commander.

November 6
Third Constant Guard F-111E lost on combat mission.

1973

January 29–April 2
Training for Australian F-111 air crews resumes at Nellis AFB.

March 17
Coronet East 99, the delivery of two F-111s from Pease AFB to RAF Upper Heyford, initiated.

March 28
Coronet East 103, the delivery of two F-111s from Pease AFB to RAF Upper Heyford, initiated.

April 12
Coronet East 78, two F-111s delivered from RAF Upper Heyford to McClellan AFB.

April 13
Coronet East 111, two F-111s delivered from McClellan AFB to RAF Upper Heyford.

April 20
Coronet East 117, the delivery of two F-111s from Pease AFB to RAF Upper Heyford, completed.

May 2
Coronet East 119, the delivery of two F-111s from Pease AFB to RAF Upper Heyford, completed.

May 8
Coronet East 64, F-111 deployment from Nellis AFB to SEA, initiated.

May 16
Coronet East 121, delivery of two F-111Es from Pease AFB to RAF Mildenhall, initiated.

May 28
Peace Lamb, the delivery of six F-111Cs from McClellan AFB to Australia, initiated.

June 6
EF-111A cockpit design review conducted by the Aeronautical Systems Division.

June 8
Coronet East 137, the delivery of two F-111s from Pease AFB to RAF Upper Heyford, initiated.

June 29
Coronet East 145, the delivery of two F-111s from Plattsburg AFB to RAF Upper Heyford, initiated.

July 13
Coronet East 147, the delivery of three F-111s from Pease AFB to RAF Upper Heyford, initiated.

August 9

Coronet East 05, delivery of two F-111s from Pease AFB to RAF Upper Heyford, initiated.

August 17

Coronet East 13, delivery of two F-111s from Pease AFB to RAF Upper Heyford, initiated.

August 24

Coronet 17, delivery of two F-111s from Pease AFB to RAF Upper Heyford, initiated.

September 11

Coronet Bolo IV, the redeployment of 12 474TFW F-111s from Takhli RTAFB to Nellis AFB, initiated.

1974

February 6

TAC's 366TFW provides five F-111 sorties in support of NORAD FTX AMALGAM ARROW 74-5.

March 26

AMALGAM ARROW 74-6, an ADC-sponsored and JCS-coordinated FTX, is accomplished, with six TAC F-111s from the 366TFW participating.

April 30

AMALGAM ARROW 74-7, an ADC exercise, initiated. The 366TFW flies six sorties in support of the exercise during the evening hours of May 1.

May 21—29

Bold Fire 3-74, a JCS-coordinated, USREDCOM-sponsored joint FTX, initiated in Yakima, Washington area. Eight 366TFW F-111s participate.

September 18

AMALGAM ARROW 75-2, a NORAD system effectiveness exercise in an ECM environment, initiated. Six F-111 aircraft from TAC's 366TFW participate.

1975

February 12

AMALGAM ARROW 75-5, a NORAD system effectiveness exercise, initiated in the 23/24 NORAD regions. Mt. Home AFB F-111s fly support (6 F-111s from 366TFW participate).

April 2

TAC provides six F-111s as target aircraft for AMALGAM ARROW 75-6, an ADC/NORAD Regions systems effectiveness exercise. The F-111s came from TAC's 366TFW.

May 6

Silver Bullet, a tactical weapons meet involving TAC's F-111 units sponsored by the 832nd Air Division, initiated at Cannon AFB.

June 15

Coronet Birdie, redeployment of 14 F-111As from Korat Air Base to Nellis AFB, initiated.

June 20

Coronet Par, the redeployment of 16 F-111s from Korat AB to the U.S., initiated. Aircraft delayed enroute at Anderson Air Force Base, Guam, for engine changes. The decision to change engines comes about as a result of investigative findings from two earlier F-111 accidents at Nellis AFB.

1976

February 22

Cape Train, deployment of 366TFW F-111s from Mt. Home Air Force Base to Osan, Korea, initiated.

March 3

Coronet Daytona, short term deployment of 474TFW F-111s from Nellis AFB to RAF Upper Heyford, initiated. Intermediate stop made at Oceana Naval Air Station when Langley AFB runway occupied.

August 19

First F-111F departs Mt. Home AFB in response to Korean contingency at 19/1827Z.

September 16

Coronet Patriot, redeployment of F-111s from Taegu Air Base, Korea, to Mt. Home AFB, initiated.

October 6

Kangaroo II, deployment of eight F-111s (366TFW) from Taegu AB to Amberly, Australia, initiated.

March 1

Ready Switch, three F-111Fs from 366TFW, Mt. Home AFB, deployed to RAF Lakenheath (initial equipment cadre), nonstop. (On March 10, 24 F-4Ds at RAF Lakenheath are transferred to Hill Air Force Base to make room for arriving F-111s.)

1977

March 10

Initial flight of EF-111A cut short when chase plane reports stress wrinkle appearance on vertical stabilizer (later found to be incorrect).

June 3

Ready Switch II Bravo initiated as 16 F-111s of 366TFW deploy and are transferred from Mt. Home AFB to RAF Lakenheath.

June 6

First squadron of 18 F-111s are transferred from Nellis AFB to Mt. Home AFB under Ready Switch program.

July 1

Ready Switch II Delta, deployment and transfer of 16 F-111s from Mt. Home AFB to RAF Lakenheath, initiated.

July 11

Ready Switch IIE, deployment and transfer of 16 F-111Fs from Mt. Home AFB to RAF Lakenheath, initiated.

July 13

Ready Switch IIF, deployment and transfer of eight F-111 aircraft from 366TFW, Mt. Home AFB, to RAF Lakenheath, initiated.

July 15

A second squadron of 18 F-111As transferred from Nellis AFB to Mt. Home AFB under Ready Switch.

August 2

Det. 3, 57TFW (F-111E OT&E) begins move from Nellis AFB to McClellan AFB (WPE). Move includes 13 officers, 77 airmen, four F-111Es, and one F-111F. Move completed August 15.

August 2
Last of four F-111A squadrons moved from Nellis AFB to Mt. Home AFB under Ready Switch designator. Six aircraft are moved on August 2.

September 14
The 27TFW begins participation in GIANT VOICE 77, the SAC-sponsored bombing and navigation competition at Barksdale AFB. Exercise ends September 27. F-111s from TAC and SAC (FB-111As) used.

October 20
Project Surge Delta, an F-111D squadron (of 27TFW, Cannon AFB) surge effort, initiated. First phase includes Exercise Bold Eagle; second phase (following the exercise) conducted at Homestead Air Force Base.

1978

January 9
First EF-111A combined DT&E/IOT&E mission flown at Mt. Home AFB.

March 3
Coronet Falcon, deployment of eight F-111As (366TFW) from Mt. Home AFB to Taegu, Korea, initiated.

July 3
Coronet Robin, deployment of eight F-111As of the 366TFW from Mt. Home to New Zealand, initiated.

July 19
Coronet Robin, deployment of eight F-111s from Ohakea, New Zealand to Korea, initiated.

August 18
Sea Crow, an electronic and ECM exercise against Navy surface vessels, is conducted by the F-111Ds of the 27TFW staging out of Mt. Home AFB.

August 30
Coronet Kingfisher deployment of eight F-111Ds (27TFW) from Cannon AFB to Gardermoen, Norway, initiated (in support of Northern Wedding).

November 25
Red Flag 79-2 realistic combat training exercise initiated at Nellis AFB. Participants include F-111s of 27TFW and 366TFW.

December 12
EF-111A DSARC convened.

1979

October 3
Coronet Beacon, deployment of six 27TFW F-111Ds from Cannon AFB through Hickam AFB to Amberly, Australia, initiated. Redeployment begins on November 19

November 5
Semifinals of Giant Voice, SAC bombing and navigation competition, initiated with 27TFW F-111D aircraft participating.

1980

January 4
EF-111A demonstration is conducted at Langley AFB, Virginia.

February 12

U.S. Ambassador to the Court of St. James, the Honorable Kingman Brewster, formally requests permission from Her Majesty's Government to deploy TAC F-111Ds to the United Kingdom in the spring of 1980 (Coronet Hammer).

April 28

Coronet Lift, deployment of twelve F-111As of the 366TFW from Mt. Home AFB, Idaho, to Incirlik, Turkey, initiated. Unit participates in a NATO exercise, Dawn Patrol.

May 7

Coronet Hammer initiated with 18 F-111Ds of the 27TFW from Cannon AFB, to Boscombe Down, United Kingdom, non-stop.

F-111 LOSSES IN SOUTHEAST ASIA

Date	Airplane Number
March 28, 1968	66-022
March 30, 1968	66-017
April 22, 1968	66-024
September 28, 1972	67-078
October 16, 1972	67-066
November 7, 1972	67-063
November 21, 1972	67-092
December 18, 1972	67-099
December 22, 1972	67-068
June 16, 1973	67-111

Close-up of FB-111A nose gives good detail of triple Plow intake, open bomb bay, and nose gear. Reason for "Aardvark" nickname is readily apparent! Author's collection.

ANNOTATED BIBLIOGRAPHY

Air Force Magazine. Washington, D.C.: Air Force Association, various issues.

An excellent reference on current Air Force activities and aircraft. F-111 information has appeared sporadically in the publication since the early 1960s.

Aviation Week & Space Technology. New York. McGraw-Hill, various issues from 1961.

Perhaps the premier American aerospace technical journal Contains a very large number of F-111–related articles from 1961 to the present Articles are accurate, authoritative, and usually quite detailed. Particularly detailed material was published on the various Congressional hearings and the controversy surrounding the F-111B.

Bowers, P.M., and Swanborough, F.G. *United States Military Aircraft Since 1908.* London: Putnam & Co., 1971.

Perhaps the best single general reference available on all U S. Air Force aircraft types Primarily a history of the various types, including much detailed technical data. Very accurate with good (though not excellent) multi-view drawings and many photos. Good description of the F-111 program. Each of the F-111 models is covered in some detail.

———. *United States Navy Aircraft Since 1911.* London: Putnam & Co., 1976.

Complimentary volume to *United States Military Aircraft Since 1908.* Also tops in its class Excellent general reference on the many U.S. Navy types. Unfortunately, almost no space is devoted to the F-111B story. However, there is good coverage of its successor, the Grumman F-14.

Coulam, Robert. *Illusions of Choice, The F-111 and the Problem of Weapons Acquisition Reform.* Princeton, N.J.: Princeton University Press, 1977.

This is the definitive work on the history of the F-111 program. Its one and only failing is that it contains no F-111 photos. However, there are several line illustrations, some charts, and some specification tables. The text is faultless. Absolutely everything anyone could possibly want to know about the F-111 is here, including dirty politics, technical problems, and operational successes and failures.

Flight International. London: IPC Transport Press, various issues since 1961.

This is perhaps the premier general reference aviation magazine in the world—and definitely the oldest: it was born in 1909. An excellent and authoritative weekly reference It is not inaccurate to refer to it as Europe's *Aviation Week.* Many excellent, and usually accurate, articles about the F-111 have appeared since 1961. Good coverage of the machine and its mission, if one is willing to dig.

Green, William. *The Observer's Book of Aircraft.* London: Frederick Warne, various editions since 1965.

This book started its annual performance in 1942. It is purposely small to fit in the pocket. William Green took over in 1952. Information is compact, accurate, and detailed. Histories are extraordinarily abbreviated, but the technical detail is as good as one will find anywhere. Good material on the various F-111 models produced over the years.

Gunston, Bill. *Attack Aircraft of the West.* New York: Charles Scribner's Sons, 1974.

This is an excellent general reference outlining in rather detailed and readable fashion the histories of the foremost attack aircraft produced this side of the Iron Curtain. Approximately a dozen aircraft are covered, including the F-111. Gunston's writing ability and knowledge combine to make a thoroughly enjoyable and educational book.

———. *General Dynamics F-111.* London: Ian Allen, Ltd., 1978.

Unquestionably the most readable and enjoyable history of the F-111 yet written. Contains many excellent photos and illustrations Gunston's writing ability is, once again, a wonder to behold. Good insight into the politics of the problem-plagued Aardvark.

Interavia, S.A. Geneva, Switzerland.

This is an outstanding monthly aviation magazine that compares in authoritativeness to *Aviation Week* and *Flight*. It is also a beautifully produced effort with superb photos, nice line drawings, and lots of detailed information. The F-111 has been covered in extreme detail in a number of issues since the early 1960s. Amazingly, in consideration of the fact that *Interavia* is a European magazine, the photos are usually fresh and not previously published.

Jones, Lloyd S. *U.S. Fighters.* Fallbrook, California: Aero Publishers, Inc., 1977.

Good general reference on the entire spectrum of USAF fighters and their predecessors F-111 coverage is good, but not particularly detailed. Good drawings provided for each type covered.

———. *U.S. Naval Fighters.* Fallbrook, California: Aero Publishers, Inc., 1975.

A sister publication to *U.S. Fighters*, this book follows a similar format and has similar depth of coverage. Section on the F-111B is good, though not particularly detailed Has a number of interest ng illustrations including drawings of Grumman's proposed XF14F fighter-interceptor.

Knaack, Marcelle Size. *Encyclopedia of U.S. Air Force Aircraft and Missile Systems: (Vol. 1) Post World War II Fighters, 1945-1973.* Washington, D.C.: United States Office of Air Force History, 1978.

With the exception of a few technical errors, this is an excellent reference and unusual in that it includes much miscellaneous information never before officially released by the Air Force. Many aircraft are covered, including the F-111. Abbreviated service histories make up the most important historical aspects of the volume Also included, however, is information outlining the number of aircraft built, the unit cost, the operating cost, and technical and service problems. An excellent reference, and it is hoped, the first of many similar volumes to come.

Stevenson, James Perry. *Grumman F-14 "Tomcat."* Fallbrook, California: Aero Publishers, Inc. 1976.

Good technical history of the airplane with much data on systems and performance. Excellent photos. Much miscellaneous information about the TFX/F-111 program, particularly that pertaining to the F-111B. Good information on the AWG-9/Phoenix missile system.

———. *McDonnell Douglas F-15 Eagle.* Fallbrook, California: Aero Publishers, Inc., 1978.

Excellent, near-definitive technical history of what is perhaps the premier fighter in the USAF inventory. Much detailed information on the aircraft and its systems. Little mention of the F-111 program, but gives good insight into fighter design philosophy and technique.

Taylor, John W.R. *Jane's All the World's Aircraft*. London: Sampson-Low/Jane's Yearbooks, various editions from 1964/65.

A perennial favorite and unquestionably the best general reference source on aircraft available. The F-111 sections are excellent and virtually faultless. Much information about the various F-111 models is contained here. All specifications are included. Excellent source for miscellaneous data such as type equipment, tire sizes, subcontractor names, etc. *Jane's* is worthy of its Rolls Royce-like reputation.

Thruelson, Richard. *The Grumman Story*. New York: Praeger Publishers, Inc., 1976.

Well done corporate-type history of Grumman with lots of miscellaneous tidbits outlining Grumman's involvement in the F-111 program. Some insightful comments about the F-111B. Unfortunately, the writer tends to be a little too corporation-oriented and suffers from a lack of objectivity. Good reading, nonetheless.

U.S. Congress. Senate. Committee on Government Operations. Permanent Subcommittee on Investigations. *TFX Contract Investigation*. Parts 1-10, Hearings, 88th Congress, 1st session, 1963.

This is an awesome collection of material outlining all the various investigations that took place during the controversy over the TFX contract award Conveniently for the historian, just about everything of a technical nature relating to the F-111 is also covered, as well as all the political activities that took place behind the scenes. Good reference, but difficult reading.

——. *TFX Contract Investigation*. Second Series. Parts 1-3. 91st Congress, 2nd session, 1970.

Similar in most respects to the aforementioned *Contract Investigation*.

——. *TFX Contract Investigation*. Report. 91st Congress, 2nd session, 1970.

Too detailed in coverage to outline here. This is must reading for anyone interested in the TFX/F-111 program. Most libraries should have a copy of this on file.

Illustration of advanced bomber (FB-111H design) of the basic F-111 airframe. Changes are numerous. Particularly noteworthy are the new teardrop-shaped intakes. The airplane is significantly larger than its predecessors There have also been studies for FB-111B and FB-111C aircraft, to date, none have reached the hardware stage and funding for the program is still in limbo.

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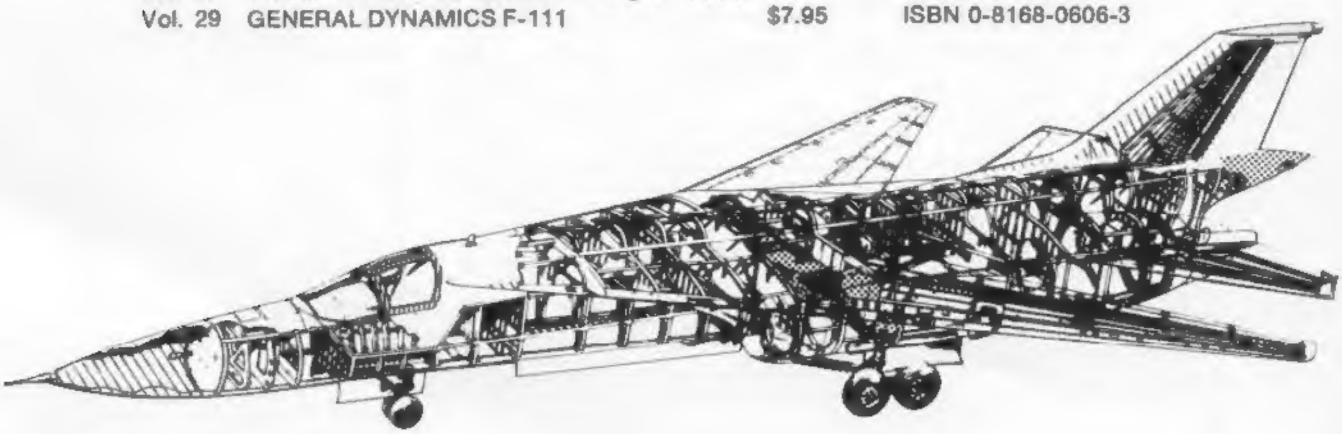

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